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U.S. DEPARTMENT OF COMMERCE  
Environmental Science Services Administration  
Research Laboratories

## HF Sky-Wave Measurements and Predictions

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BOULDER, COLO.  
JUNE 1970

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# HF SKY-WAVE MEASUREMENTS AND PREDICTIONS

## (Task 2.6 g of Addendum No. 2)

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L. L. Melanson, and B. C. Willmarth

Measurements for the month of April 1969 were made on a 2.666-MHz east-west path between Long Branch, Illinois, and Boulder, Colorado, to validate current ESSA/ITS prediction programs. After the difference between the measured observations and the computer calculations had been determined, additional path calculations centered about the Boulder receiving site were made to identify potential interfering sources. Point-to-point calculations along quadrature radials were used, with the range being incremented five times along each radial between the limits of 500 and 5000 km.

The analysis determines the required transmitter power to produce a CW signal via the predominant mode which is 90 percent reliable and 12 dB above the controlling noise (atmospheric, man-made, galactic, or a combination). The averaged night values of required transmitter power including an 8-dB correction factor found from the measured observations, are tabulated by month as a function of both the bearing and range.

Key Words: High-frequency, ionospheric, measurements, predictions, signal-to-noise, sky-wave, transmission, transmitter power.

### 1. INTRODUCTION

A short range (<100 km) ground-wave communication system operating in the 2-to-3-MHz region of the spectrum may be subject to accidental or deliberate interference from sky-wave signals from distant transmitters operating on the same frequency. Since this band has many transmitter allocations for each channel (IFRB, 1969), a study was undertaken to determine the interference threat these allocations might present.

Signals from a transmitter operating on 2.666 MHz at Long Branch, Illinois, were measured at Boulder, Colorado. The results were used to confirm the validity of the ESSA/ITS prediction program (Barghausen et al. , 1969). The program was then used to predict the transmitter power necessary to cause intolerable interference on this frequency from various distances. This pilot study illustrates an available method for determining potential sky-wave interference.

## 2. THE EXPERIMENT

For verification of the present ESSA/ITS HF sky-wave predictions, a transmitter operating in the 2-to-3-MHz band was established at Long Branch, Illinois, and monitored in Boulder, Colorado. The path distance is 1288 km. Measurements of the nighttime signal strength in a number of adjacent 100-Hz channels were recorded and analyzed for April 1969.

### 2.1 Instrumentation

The system used for the Long Branch-to-Boulder circuit was representative of those expected for a narrow-band (100 Hz) ground-wave communication system. The system consisted of a CW transmitter operating on a frequency of 2.666240 MHz, with the receiving terminal equipment being a 100-Hz IF bandwidth receiver.

#### 2.1.1 Transmitting Equipment

The transmitting terminal parameters for computer circuit simulation were:

Location -	Havana, Illinois 40.30°N, 90.06°W
Frequency -	2.666240 MHz
Power -	1.2 kW (input to antenna)
Emission -	Continuous wave

Antenna - Sloping vee; feed height 80 ft (24.4 m);  
termination height, 20 ft (6.1 m);  
semi-apex angle,  $35^{\circ}$ ; leg-length, 250 ft  
(76.2 m); orientation, on great circle to  
receiver site.

Because preliminary daytime observations indicated that the signals could not be detected in Boulder, most data were recorded at night. Both the days and hours of operation are indicated in table 1.

### 2.1.2 Receiving equipment

The receiving terminal parameters for computer circuit simulation were:

Location - Boulder, Colorado,  
 $40.11^{\circ}\text{N}$ ,  $105.24^{\circ}\text{W}$

Frequency -  $2.666\text{ MHz} \pm (\approx 500\text{ Hz})$

Required  
SNR - 20.0 dB (signal-to-noise power ratio)

Man-made  
noise - Suburban (equivalent to -148.6 dBW)

Antenna - Vertical monopole; quarter wavelength  
at 2.666 MHz.

The receiving terminal system shown in figure 1 consists of a Hammarland SP 600 receiver, with the local oscillator replaced by a programmed frequency synthesizer. The receiver's first IF output was heterodyned to 10 kHz and passed through a square 100-Hz bandpass filter. The filter output was rectified and fed to both a strip-chart recorder and an FM tape recorder. The receiver's local oscillator was programmed to cover 1000 Hz of RF bandwidth in 10 steps of 100 Hz each at a rate of 12 steps per hour. Thus, each step's sample time was 5 min, with the fifth 100-Hz step centered on the desired Long Branch transmitter frequency of 2.666240 MHz.

Table 1. Data Recording Times.

Day of Year 1969	Time (UT)*													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
094		②			⑤			⑧			⑪	⑫		
099			③			⑥			⑨			⑫	⑬	
100 **			④				⑦			⑩			⑬	
101		②			⑤			⑧			⑪	⑫		
105		2			5			8			11	12		
106	1			4			7			10	11			
108			3			6			9			12	13	
113			③			⑥			⑨			⑫	⑬	
114		②			⑤			⑧			⑪	⑫	⑬	⑭
115			④				⑦			⑩			⑬	
119	1			4			7			10	11			
120		2			5			8			11	12		
121		2	3			6			9			12		
123		2	3			6			9			12		
126		2	3			6			9			12		
127	1			4			7		9		11			
129		2			5			8		10		12		
135		2			5			8		10		12		
140		2			5			8		10				
142	1			4			7			10	11			
TOTAL	4	11	6	6	8	6	6	8	7	8	9	13	5	1

Circled hours are used in the data analyzed in table 2.

\* Local time at path midpoint corresponding to 1 UT is 18.5 hrs.

\*\* Day 100 is equivalent to April 10.

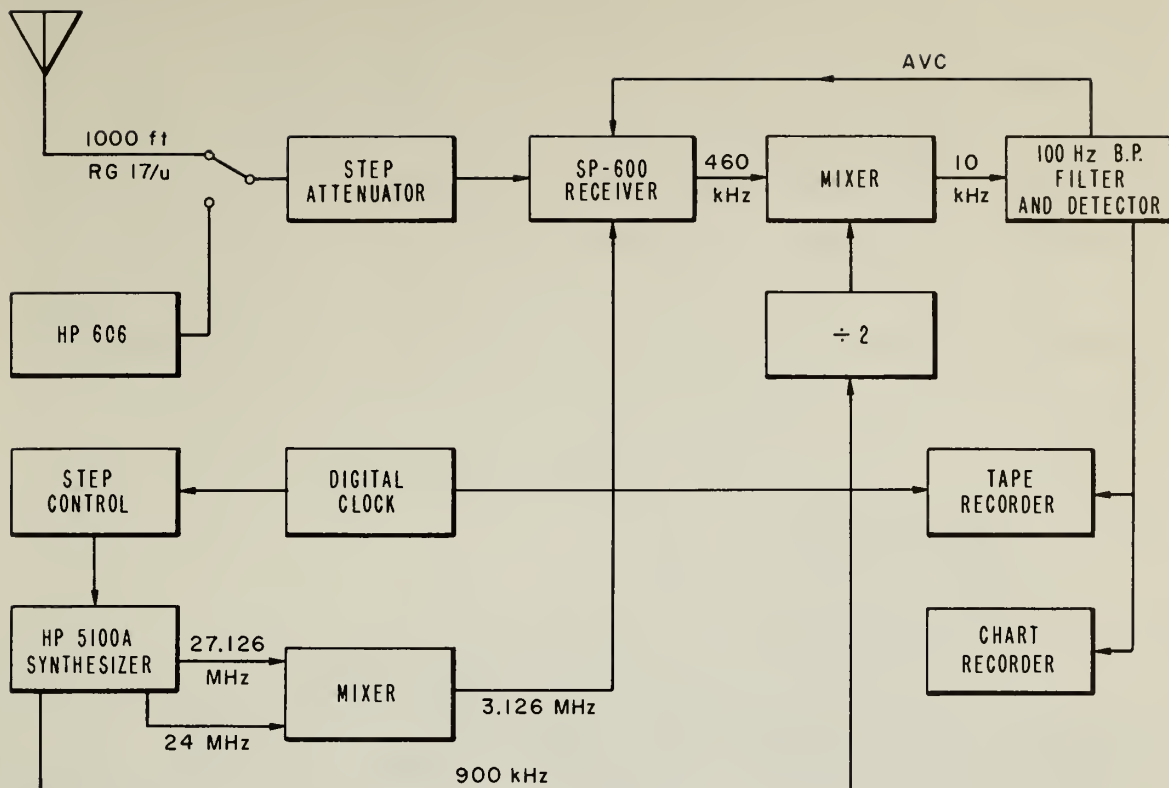


Figure 1. Receiving System.

The amplitude stability of the receiving equipment and tape recorder were frequently checked by means of a 1-millivolt signal generator reference level and an impedance matched step attenuator for calibration.

The detected output voltage of the receiver system corresponded to a level of 15.5 dB above the measured field strength in microvolts per meter. The field strength used for this calibration was produced by a 2.666-MHz transmitter located at a field site near Erie, Colorado, and measured by a calibrated field intensity meter at the receiving antenna. The 15.5-dB factor was used in determining the actual field strength from the recorded analog voltages.

## 2.2 Data Analysis

The analog data obtained from field measurements were recorded on FM magnetic tape that had been programmed to interface with available ESSA/ITS data analysis equipment. The calibration and received signal voltages were both processed on the Time Data 100 (TD-100) "hard-wired" computer to produce autocorrelation functions and digital cumulative amplitude distributions. The block diagram in figure 2 illustrates the method used.

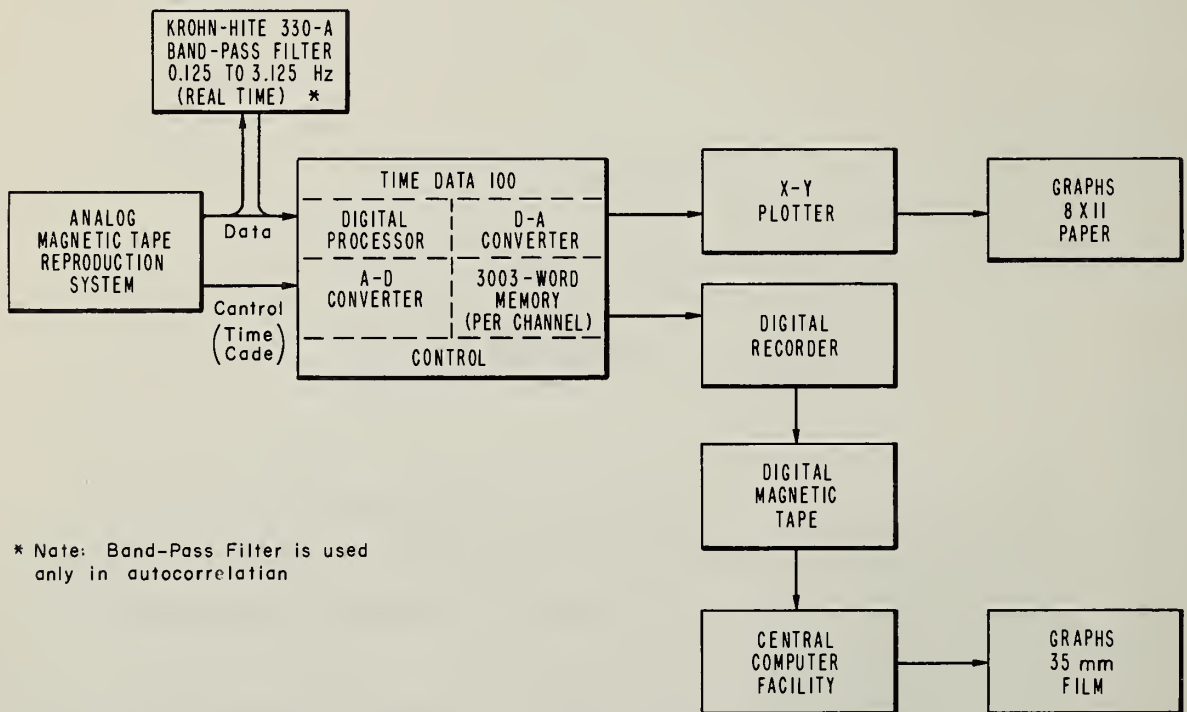


Figure 2. Data reduction system.

In the data reduction process the first step was the generation of an amplitude histogram by sampling the recorded analog signal 62 times per second with an aperture width of  $16\mu\text{s}$ . Each sample was

converted to a digital integer value between 000 and 254 (8 bits). This integer value established the address in a 255-word section of memory to be incremented by one. Thus, at the end of the 5-min time segment, the accumulated value in each word represents the number of times the corresponding discrete amplitude occurred in the input function.

The content of the 255-word memory was recorded in digital form on magnetic tape for final processing. The ERL central computer facility (CDC 3800) processed the histogram amplitude distributions of the received 2.666-MHz signals and of the noise of adjacent channels to produce the plots shown in appendix D. The amplitude probability distribution (APD) curves for the two 100-Hz channels adjacent to the signal channel show a marked change from those of the other noise channels. The APD curves of the desired signal are identified as being recorded 20 min (MIN 20) after the hour. The decibel calibration curves referenced to stable 1-millivolt level are identified as MIN 70. Figure 3 shows an example of a calibration curve for April 23. The horizontal scale displacement toward the right aids the visual identification of the increasing attenuation levels.

A linear decibel transfer function was assumed for the collected data generated in the computer program by which the CRT\* plots were made. Because the daily calibration plots showed variations due to the actual nonlinearity of the receiving and recording equipment, manual scaling and transferring of the individual APD plots to a standard scale were required as intermediate steps. Table 2 identifies the analyzed signal data scaled for the 10, 50, and 90 percentages of time levels.

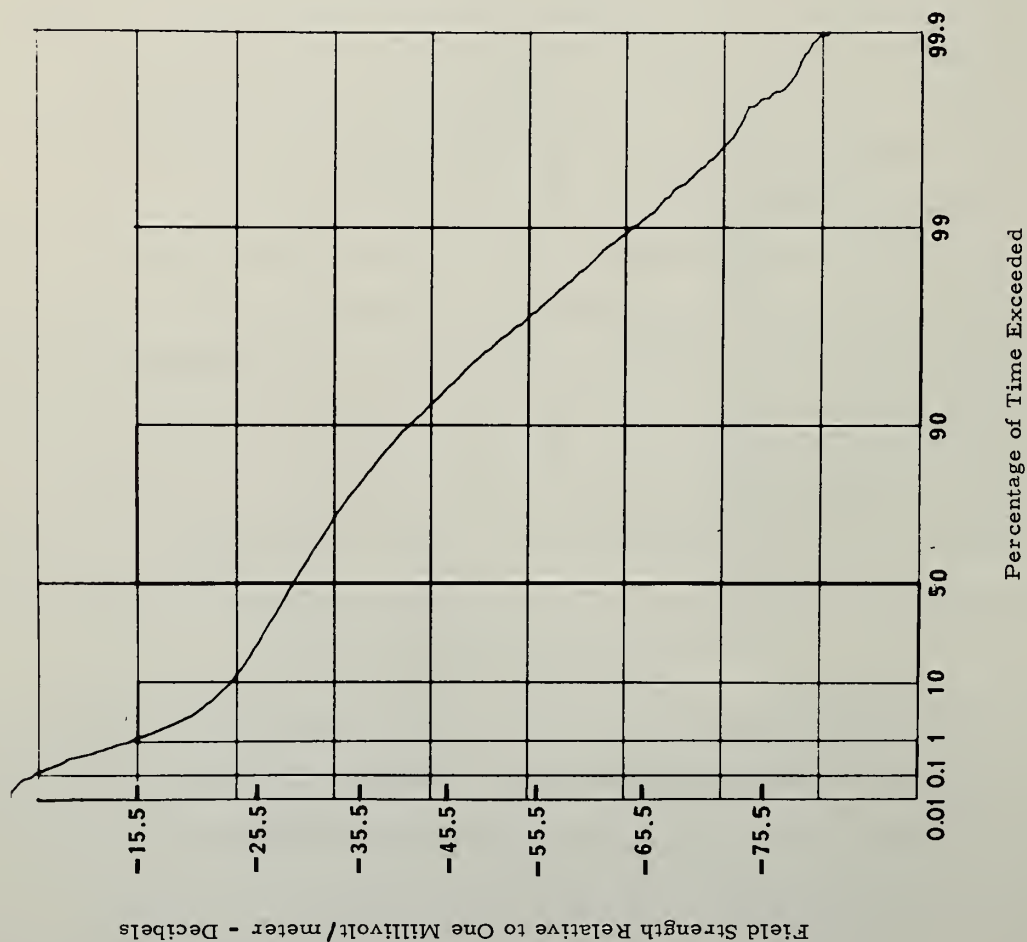
### 2.3 Discussion

The 2.666-MHz transmissions from Long Branch, Illinois, (WWI) were consistently received at Boulder, Colorado, during the nighttime and relatively few consistent and/or strong additional signals were

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\* CRT is an abbreviation for cathode ray tube.

Day 113, Hr. 03; Min. 20



Day 113, Hr. 00, Min. 70

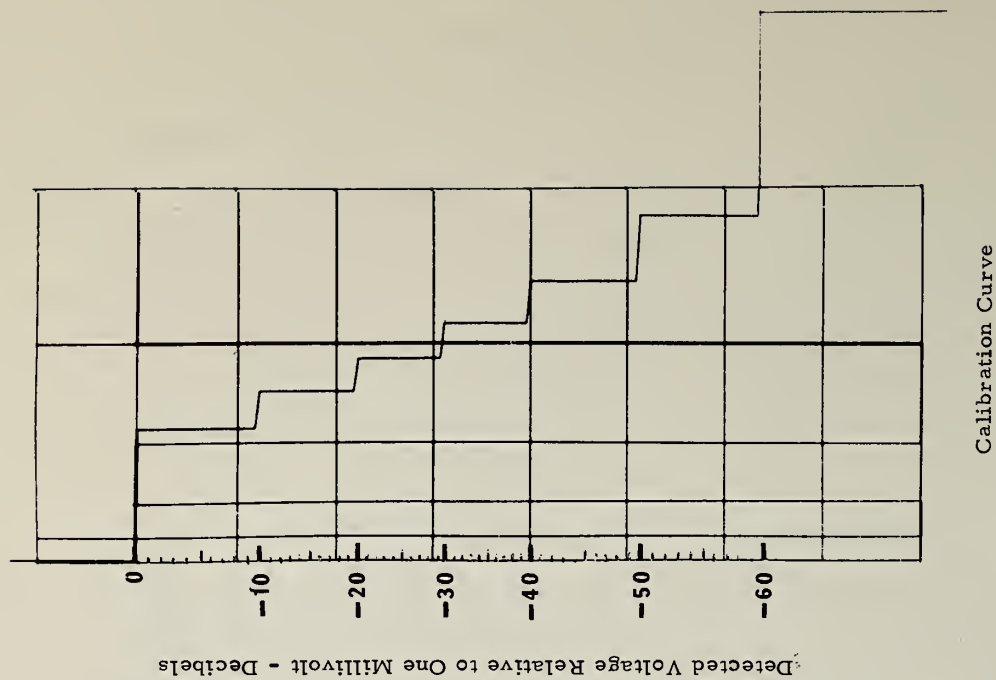


Figure 3. Sample CRT microfilm APD curve and calibration for day 113.

Table 2. Analyzed 5-min Recordings of Receiver Voltage for Desired Transmission Channel (Decibels Relative to 1 Millivolt).

Day of		Time (UT)													
Year 1969	Percentage Level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
94	10%		-03			-02			00			-01	-30		
	50%		-10			-10			-05			-06	-40		
	90%		-22			-28			-16			-17	-55		
99	10%			-13			-06			-08			-30	-42	
	50%			-19			-12			-13			-38	-45	
	90%			-31			-25			-24			-48	-50	
100	10%				-09			-03			-05			-58	
	50%				-48			-08			-10			-61	
	90%				-63			-17			-19			-63	
101	10%		-08						-05			-01	-35		
	50%		-15			-10			-10			-08	-44		
	90%		-25			-23			-22			-20	-54		
113	10%			-08			-03			-02			-31	-45	
	50%			-14			-08			-08			-39	-52	
	90%			-25			-17			-18			-53	-62	
114	10%		-07			-05			-05			-09	-35		
	50%		-12			-11			-09			-14	-39		
	90%		-21			-22			-18			-23	-44		
115	10%				-09			00			+05			-45	-51
	50%				-15			-06			00			-55	-60
	90%				-24			-15			-11			—	—

recorded over the 1000-Hz band sampled. To confirm that no other signal than WWI was being received on 2.666240 MHz, an overnight recording was made on June 26, 1969, with the transmitter specially keyed to produce long noise breaks. No additional station activity, other than what could be attributed to noise, was recorded on this date. A second overnight recording of the frequency range 2.5 to 3.0 MHz based on 5000 100-Hz samples, two per second, suggested that night occupancy of this 500-kHz sector of the spectrum was very similar to the more restricted 1-kHz section, i. e., relatively low occupancy as received at Boulder during the test period.

Figure 3 shows a microfilm APD reproduction resulting from a 5-min CW signal starting at 03:20 universal time on April 23, 1969 (day 113). Also shown is the calibration for this date. The CRT plots are displayed on a linear decibel scale versus a Rayleigh probability distribution scale. Figure 4 is the result of transcribing several APD points at the 0.1, 1, 10, 50, 90, and 99 percentage of time levels to a common scale. The figure shows the median value as a curve with scatter points for hours 2 through 11 UT.

Three autocorrelation functions of the received signal for day 94 (April 4) are shown in figure 5 as computed with the TD-100 and the X-Y plotter. The autocorrelation decays in a few seconds to zero and then oscillates about zero for larger time lags.

### 3. THE MODEL

#### 3.1 General Description

Computer programs are available that predict many of the indicators of performance for ionospheric telecommunication systems (Barghausen et al., 1969), such as propagation mode, takeoff and arrival angles, time delay, probability of ionospheric support, median available signal-to-noise ratio, median field strength at the receiving site, circuit

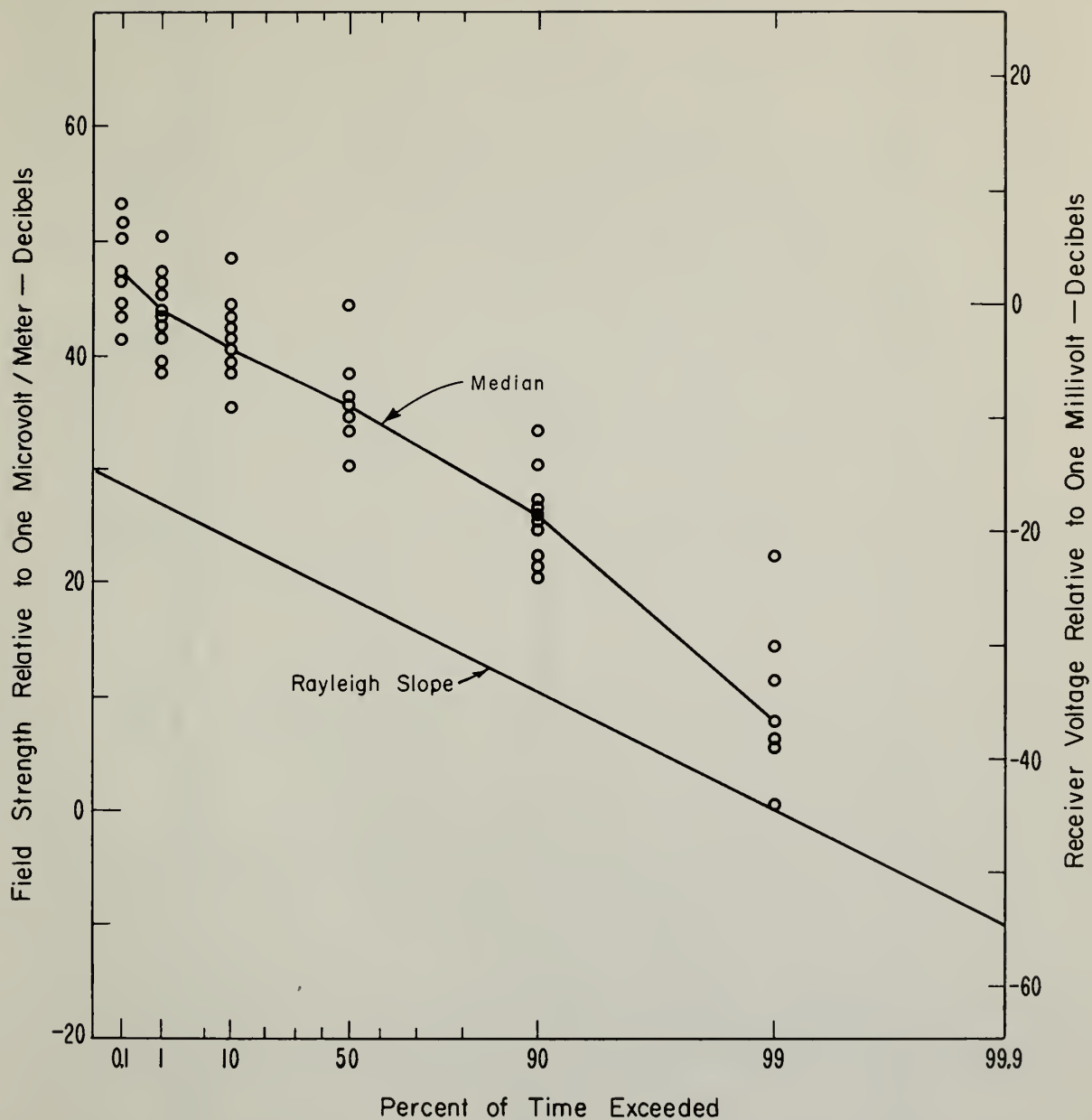


Figure 4. Channel 5 amplitude probability distributions for hours 2 through 11 UT for days 100, 101, 113, 114, and 115.

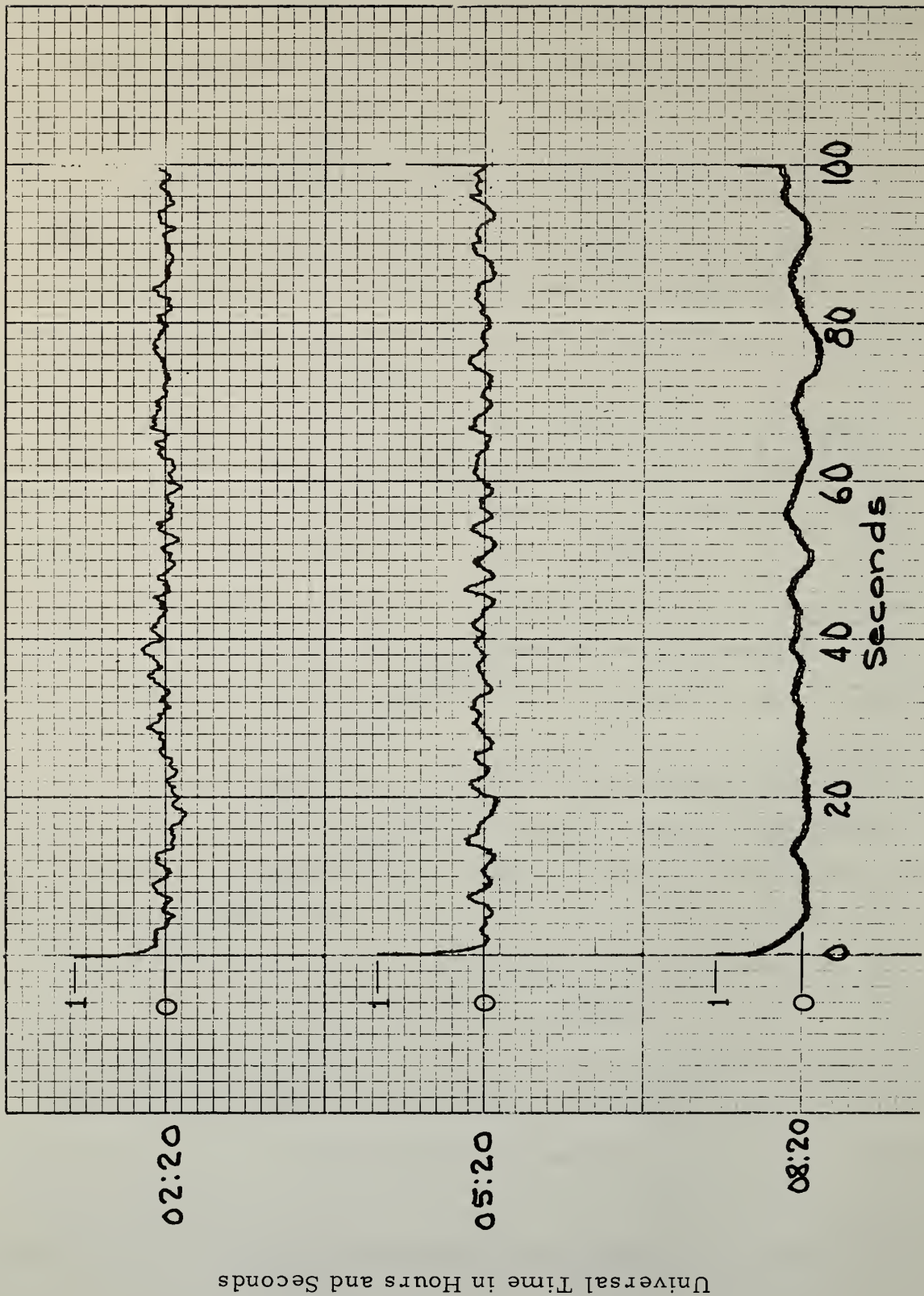


Figure 5. Autocorrelations for day 94.

reliability, and service probability. The reverse process of determining, for a given communication circuit, the transmitting power required for a given value of circuit reliability or service probability and time availability on HF ionospheric systems is equally desirable (Rosich, 1969).

These long-term monthly median prediction estimates of system performance are based on such parameters as season, solar activity level, the geographic location of the transmitting and receiving antennas, and required SNR. The HF power prediction program has been described by Rosich (1969) and will not be reviewed in detail here.

In this study, a computer print-out presentation was developed whereby potential interference can be evaluated on the basis of the ESSA/ITS prediction model. The evaluation is complicated by the fact that the signal strength depends strongly upon frequency, time of day, and other system parameters.

It should be kept in mind that the model yields only long-term estimates of system performance and does not include short-term phenomena.

It is convenient and practical to distinguish between short-term and long-term variations of signal strength. Variability within a single hour is arbitrarily classified as "short term", and is allowed for by a minimum hourly median required SNR. This additional SNR quantity is simply that number of decibels by which the predetection hourly median rms signal level exceeds this rms noise level in order to provide the specified grade of service during that hour. The study of long-term variability is then concerned with the variability of these hourly medians.

### 3.2 Discussion

Once the circuit terminal hardware parameters have been determined, the signal-to-noise ratio (SNR) is the primary factor in determining circuit reliability, which is directly associated with a grade of service. The grade of service defines the type of communication transmissions desired -- for example, the percentage of error-free messages in teletype, the intelligibility of voice, or the percentage of satisfactory observations of facsimile. A minimum required SNR is associated with the desired grade of service (Akima et al., 1969). The SNR specified by the program user as input data is determined from the class of emission, modulation index, modulation rate, signal codes, error-correcting schemes, effects of fading, noise reducers, optimum modulation detection techniques, and diversity schemes. The required SNRs for satisfactory service for some systems are listed in appendix A as reproduced from Barghausen et al. (1969).

The procedure for calculating circuit reliability for a particular path and frequency consists of (a) determining the maximum frequency that will be supported by the ionosphere; (b) calculating the probability that the specific frequency of interest will be propagated at a given hour within the month; (c) finding the distribution of SNR from the median and standard deviation of both signal power and noise power; (d) calculating the probability that the SNR will exceed the required SNR; and (e) multiplying the two probabilities from (b) and (d) to give an estimate of circuit reliability.

The median value of received signal power  $P_e$  required for minimum acceptable grade of service during the month at a given hour is (CCIR, 1964)

$$P_e = F_{am} + R_{md} + B - 204 \text{ (dBW)} , \quad (1)$$

where

- $F_{am}$  = median of the hourly values of radio noise power density  $F_a$  within a seasonal time block (dBW/Hz),  
 $R_{md}$  = required system signal-to-noise power density ratio in 1-Hz bandwidth, (dB), and  
 $B$  = effective receiver bandwidth (dB:  $\log_{10} b$ ;  $b$  in Hz).

The values of  $F_{am}$  are representative of those that would be obtained with a short vertical lossless antenna over a perfectly conducting plane earth. The use of other antennas requires some correction because of directivity and polarization. The available signal-to-noise ratio,  $R_{S/N}$ , at the receiving antenna terminals is calculated by combining the received signal power with the received noise power:

$$R_{S/N} = S - N \text{ (dB)} , \quad (2)$$

where

$S$  = monthly median signal in decibels for the specific hour, and

$N$  = monthly median of the hourly median radio noise power in decibels.

The probability,  $q_{S/N}$ , that the available signal-to-noise ratio,  $R_{S/N}$ , exceeds the required SNR,  $R_{md}$ , is evaluated by the chi-square probability functions. The chi square,  $\chi^2$ , or gamma distribution is used in order to represent reasonably well both the positively and negatively skewed data distributions that have been incorporated into the computer prediction programs.

The  $\chi^2$  probability distribution function is convenient because the ionospheric F-layer data distribution and other physical data based on observations have been recorded and reduced for years in terms of only the 10, 50, and 90 percent points. These forms of ionospheric data reduced to numerical maps and tables are represented in the ESSA/ITS computer prediction program and associated data tapes. The statistical model is fitted to these three points and evaluated when a probability of occurrence other than 10, 50, or 90 percent is needed. Since in computer applications the entire distribution has to be estimated, it is

assumed that the observed variable can be approximated by a linear function of a chi-square variable with unknown degrees of freedom. The many detailed uses of the  $\chi^2$  probability distribution function for determining the expected system performance can be found in recent reports (Barghausen et al. , 1969; Zacharisen and Crow, 1970).

Two different measures of expected system performance are provided by the prediction program (see app. B). The first is based on circuit reliability, discussed earlier in this section, which is obtained from monthly median estimates of all operational parameters and their distributions. Circuit reliability represents simply the expected fraction of days in the month at the given hour that successful communication is expected at the operating frequency of interest.

An alternate method gives estimates of the service probability, which is defined as the probability of obtaining a predetermined grade of service or better during a specific percentage of time. It includes estimates of the prediction uncertainties associated with the operational parameters as a function of the percentage of time the specified grade of service is required.

#### 4. COMPARISON AND EVALUATION

Examination of data from field measurements converted into cumulative distribution functions showed that the maximum median field strength occurred between 2 and 11 UT. The median value for the data taken (5-min sample/hr) during all these hours was 34 dB above  $1 \mu\text{v/m}$ , with upper and lower deciles of 39 dB and 23 dB, respectively. Figure 6 shows an averaged plot of analyzed data for each hour taken during this test period; these data are tabulated in table 2. The hourly predicted median values for April are plotted for comparison with observed medians. The computed median value for the dominant 1 F mode during the night hours of 3 through 11 UT was 26 dB above  $1 \mu\text{v/m}$ . Although the predicted median field strengths were about 8 dB lower than those

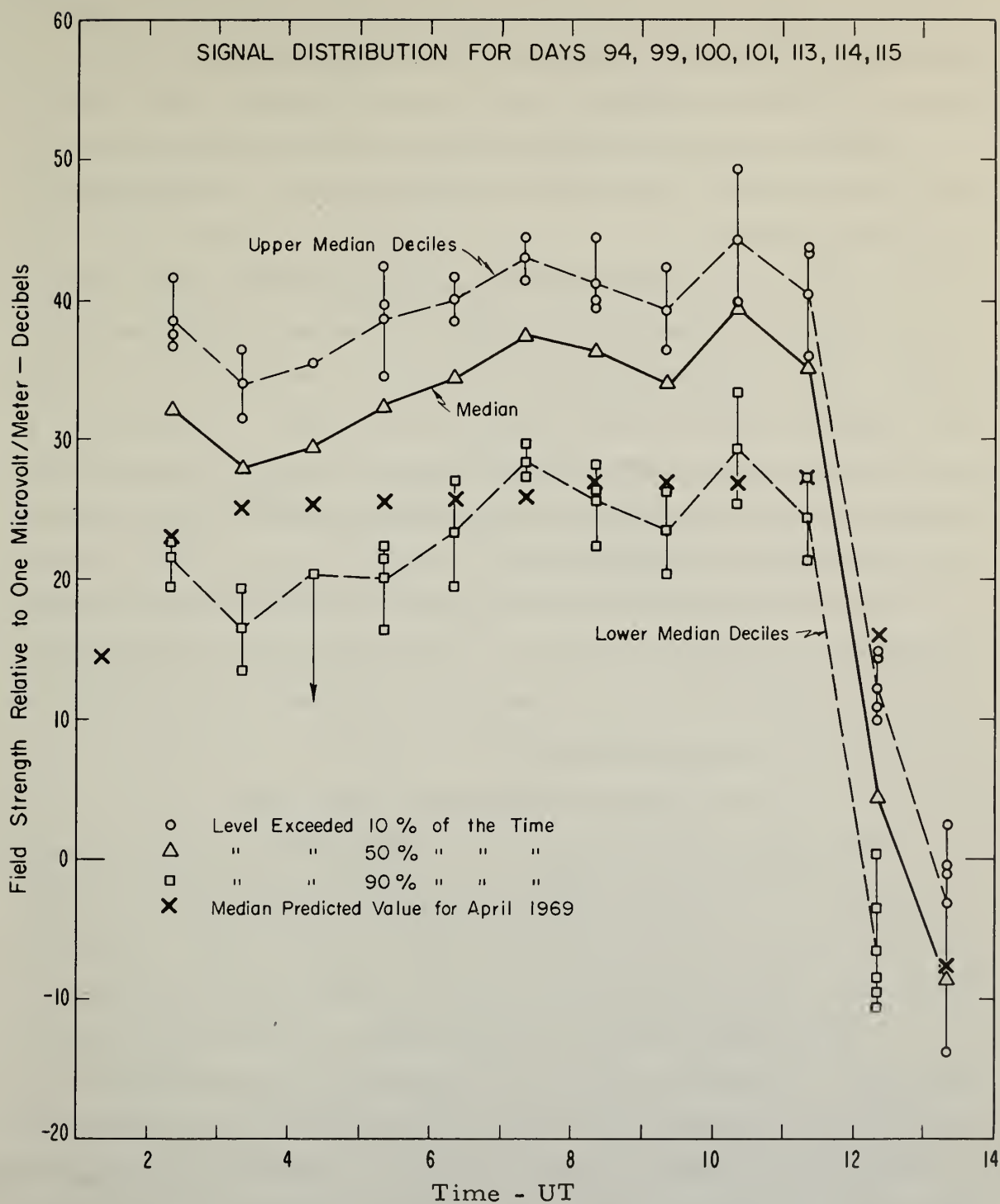


Figure 6. Comparison of measured and predicted field strengths.

observed, the general agreement between the observations and predictions is considered very good. This result is in agreement with other comparisons between predictions and observations for other frequencies and other paths as shown in section 7.6 of Barghausen et al. (1969), where 8 months of calibrated data of observed monthly median field strength values are plotted together with the values predicted by the computer program. The two sets of curves agree, on the average, within about 7 dB.

A point of interest is that the calculations indicate a 3.7-dB median signal difference for the night hours between the 1 F and 2 F modes. The 2 F mode is dominant during the sunrise and sunset transition hours, and the 1 E mode is dominant for 14 UT. The median arrival angles are 22 and 41 degrees for the F modes. Additional arrival angle and transmitter power statistics for April, May, and June are tabulated in appendix C.

The computer program contains a provision for calculating the likelihood of multipath transmissions where this source of interference can cause intolerable bit error rates for high speed data transmission systems, but multipath propagation is not considered here.

## 5. TRANSMITTER POWER ANALYSIS

The demonstrated adequacy of the ESSA/ITS ionospheric model to estimate HF circuit performance permits a computerized study of potential HF sky-wave interference. The required distant transmitter power that will cause interference at the Boulder site is estimated.

The distance and the required transmitter power level that is expected to exceed the receiver's threshold level were evaluated as follows: (1) On the basis of limited measurements, the calculated median field strengths from the ITS model appear to be low by approximately 8 dB; (2) the predicted power levels with 90 percent reliability and an assumed SNR of 20 dB produced estimated power levels 20 dB higher

than the desired threshold power level; (3) thus, the level to exceed the receiver's noise threshold estimated from calculated data requires a 12-dB reduction.

The field measurements and the computer analysis of the Long Branch-to-Boulder circuit initially were carried out independently. The parameters for computer circuit simulation are given in section 2.1. Based on sunspot number information for April, the HF prediction program "HF MUFES2" was used to determine the circuit's median monthly operational SNR and reliability for each hour of the day for an operating frequency of 2.666 MHz. This prediction is included as appendix B.

After it had been determined from the model that the night hours were the only hours that would support communication as well as interference, data for hours 1 through 11 UT only were produced and analyzed. The required transmitter power data were generated with the prediction program "HFPOWERX" using the same system characteristics as before, except for a fixed reliability of 90 percent and a changed transmitting antenna. The transmitting antenna was changed to a quarter-wavelength vertical radiator. The power to cause interference in the directions north, east, south, and west of the Boulder receiving site at distances of 500, 1000, 2000, 3000, 4000, and 5000 km were calculated. The required transmitter power data contained in appendix C were based on the 6-month data tape with month and sunspot numbers: April, SSN = 106.0; May, SSN = 105.7; June, SSN = 104.6.

The computer-simulated noise threshold corresponds to a 20-dB level for a 100-Hz band. For satisfactory operation above this threshold, a SNR of 20 dB was assumed. Any modification in the total operational system gain that increases or decreases either the actual or apparent received signal strength likewise modifies the assumed required SNR. An increase in the received signal strength may result from (a) the use

of increased antenna power gains without a corresponding increase in noise gain for receiving antennas and/or (b) increased transmitter power. Apparent gain is achieved by reducing the signal-to-noise power ratio required at the receiver terminals through use of improved receiving and transmitting terminal equipment or of receiving antennas that discriminate more strongly against noise.

Tables 3 through 8 summarize, under two headings, the maximum and minimum (with respect to bearing) of the average power level for the 3-month period April, May, and June, that will achieve 90 percent reliability at the Boulder receiver site. The standard deviation of the values entering into each average is also tabulated. These tables are derived directly from appendix C. Each table (one for each of the six distances) contains four subgroups for hours 1 through 11 UT. Subgroups are identified by the bearings contained in the summation, that is, one bearing, two bearings, three bearings, and all bearings calculated.

If we assume that the predictions for other distances are equally high, as determined in section 4, the predicted minimum power levels in tables 3 through 8 should be lowered by 12 dB to obtain threshold power levels, since the calculations given in appendix C were based upon an equivalent SNR of 12 dB.

The minimum nighttime CW power (dBW) required for detectable signal levels at the Table Mountain field site in a 100-Hz bandwidth at 2.666 MHz with 90 percent reliability is summarized in table 9, which gives estimated mean transmitter power levels north, east, south, and west of the receiver at distances of 500, 1000, 2000, 3000, 4000, and 5000 km for April, May, and June, 1969.

We can conclude that it would be relatively easy to cause intolerable interference with a transmitter as far away as 5000 km. This conclusion includes the assumption that the difference between observations and predictions at 1288 km on an east-west path is 8 dB and that this same correction is applicable at the other distances.

Table 3. Summary of Maximum and Minimum Mean Power Levels (dBW) at 500 km\* for Interference Which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	S	30.3	6.9	W	35.3	4.8
2	S	22.0	5.7	N	27.3	6.8
3	S	22.0	2.8	E	29.0	4.2
4	S	24.0	0.8	E	31.3	2.6
5	S	27.0	0.0	E	33.0	2.2
6	S	28.0	0.8	E	33.0	2.2
7	S	28.3	0.5	E	34.7	2.4
8	S	28.0	0.0	E	33.7	2.4
9	W	28.0	0.8	E	32.3	2.6
10	S	24.7	0.5	E	28.3	1.9
11	S	22.3	1.2	E	24.7	0.9
1	E S	32.0	7.7	N W	35.0	5.8
2	E S	23.8	7.2	N W	27.3	6.5
3	S W	22.3	2.6	N E	26.3	4.8
4	S W	24.8	2.0	N E	29.2	4.1
5	S W	27.0	1.0	N E	30.8	3.8
6	S W	28.2	1.1	N E	31.3	3.1
7	S W	28.3	0.9	N E	32.2	3.7
8	S W	28.0	0.6	N E	31.3	3.8
9	S W	28.3	0.7	N E	30.8	3.3
10	N S	25.0	2.4	E W	27.2	1.9
11	N S	22.8	1.3	E W	24.2	1.2
1	N E S	32.9	7.5	N E W	34.6	6.7
2	E S W	25.0	7.1	N E W	26.8	7.1
3	N S W	22.8	3.1	N E W	25.1	4.5
4	N S W	25.6	3.1	N E W	28.0	4.0
5	N S W	27.6	2.5	N E W	29.6	3.7
6	N S W	28.7	2.1	N E W	30.3	3.0
7	N S W	28.8	2.0	N E W	30.9	3.6
8	N S W	28.3	2.2	N E W	30.2	3.5
9	N S W	28.7	2.1	N E S	30.1	2.9
10	N S W	25.3	2.1	N E W	26.6	2.6
11	N S W	23.1	1.4	N E W	23.9	1.3
1	NESW	33.5	7.0			
2	NESW	25.6	7.1			
3	NESW	24.3	4.4			
4	NESW	27.0	3.9			
5	NESW	28.9	3.4			
6	NESW	29.8	2.8			
7	NESW	30.3	3.3			
8	NESW	29.7	3.2			
9	NESW	29.6	2.7			
10	NESW	26.1	2.4			
11	NESW	23.5	1.4			

\* Centered on Boulder, Colorado

Table 4. Summary of Maximum and Minimum Mean Power Levels (dBW) at 1000 km\* for Interference which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	S	49.3	7.4	N	60.7	7.4
2	S	30.3	9.8	N	43.0	13.1
3	S	20.3	1.2	N	31.7	9.4
4	S	21.0	0.8	E	32.3	2.6
5	W	21.7	1.7	E	32.3	2.6
6	S	23.0	1.4	E	33.0	2.8
7	W	24.0	0.0	E	34.0	2.8
8	W	22.3	0.5	E	33.3	3.3
9	W	22.3	0.5	E	30.0	2.8
10	W	21.7	0.5	E	26.0	2.2
11	S	19.7	1.7	E	29.3	7.5
1	E S	50.0	9.5	N W	60.2	6.3
2	E S	33.5	11.2	N W	42.8	10.6
3	S W	23.7	6.5	N E	30.7	7.2
4	S W	21.7	1.6	N E	29.8	4.2
5	S W	22.3	1.7	N E	29.7	4.4
6	S W	23.5	1.3	N E	30.0	4.7
7	S W	24.0	1.0	N E	30.7	5.1
8	S W	23.2	1.3	N E	29.7	5.3
9	S W	23.5	1.8	N E	28.0	4.1
10	S W	21.7	1.4	N E	24.3	3.1
11	S W	20.3	1.7	N E	29.3	6.9
1	E S W	53.2	9.4	N E W	57.0	9.4
2	E S W	36.6	11.0	N E W	40.8	11.3
3	E S W	25.7	6.4	N E W	29.4	7.7
4	N S W	23.6	3.8	N E W	27.3	5.1
5	N S W	23.9	3.6	N E S	27.4	4.9
6	N S W	24.7	3.1	N E W	28.0	4.8
7	N S W	25.1	3.2	N E S	28.4	5.3
8	N S W	24.1	3.0	N E S	27.8	5.1
9	N S W	24.3	3.1	N E S	26.9	3.9
10	N S W	22.0	2.2	N E S	23.4	3.1
11	N S W	23.3	5.7	N E W	26.6	6.9
1	NESW	55.1	9.5			
2	NESW	38.2	11.9			
3	NESW	27.2	7.7			
4	NESW	25.8	5.2			
5	NESW	26.0	5.0			
6	NESW	26.8	4.7			
7	NESW	27.3	5.0			
8	NESW	26.4	5.0			
9	NESW	25.8	3.9			
10	NESW	23.0	2.8			
11	NESW	24.8	6.7			

\* Centered on Boulder, Colorado

Table 5. Summary of Maximum and Minimum Mean Power Levels (dBW) at 1000 km\* for Interference which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	E	67.0	18.0	W	96.0	4.2
2	S	43.0	13.6	W	77.0	9.9
3	S	24.0	0.0	N	51.3	10.7
4	S	24.0	0.0	N	40.0	1.4
5	W	24.7	0.5	N	42.3	2.9
6	W	25.0	0.0	N	42.3	2.5
7	W	25.0	0.0	N	42.3	2.5
8	W	25.0	0.0	E	37.7	2.4
9	W	23.7	0.5	E	33.7	1.7
10	W	23.7	0.5	E	34.3	3.4
11	S	23.3	0.9	N	48.7	15.5
1	E S	71.8	14.6	N W	93.3	6.6
2	E S	43.3	12.7	N W	76.0	14.5
3	E S	30.5	6.6	N W	48.7	14.1
4	S W	25.5	2.5	N E	39.0	1.7
5	S W	25.2	1.1	N E	40.5	3.2
6	S W	25.3	0.9	N E	41.0	2.8
7	S W	25.7	1.4	N E	40.5	3.0
8	S W	25.5	1.6	N E	34.5	3.9
9	S W	25.0	2.6	N E	32.5	2.4
10	S W	24.7	1.4	N E	32.5	3.4
11	S W	23.5	0.8	N E	48.5	15.3
1	N E S	78.1	15.4	N S W	87.8	10.4
2	N E S	53.9	20.9	N E W	65.2	20.5
3	E S W	35.7	13.1	N E W	44.8	12.8
4	E S W	29.7	6.3	N E W	35.0	6.1
5	E S W	29.7	6.6	N E S	35.6	7.5
6	E S W	30.1	6.9	N E S	35.9	7.6
7	E S W	30.0	6.4	N E S	35.8	7.2
8	N S W	27.4	3.3	N E S	31.7	5.3
9	N S W	27.1	3.9	N E S	30.4	3.9
10	N S W	26.7	3.3	N E S	30.2	4.3
11	E S W	31.8	14.6	N E W	40.2	17.1
1	NESW	82.6	15.6			
2	NESW	59.7	21.3			
3	NESW	39.6	14.3			
4	NESW	32.3	7.1			
5	NESW	32.8	8.0			
6	NESW	33.2	8.1			
7	NESW	33.1	7.8			
8	NESW	30.0	5.4			
9	NESW	28.8	4.5			
10	NESW	28.6	4.7			
11	NESW	36.0	16.6			

\* Centered on Boulder, Colorado

Table 6. Summary of Maximum and Minimum Mean Power Levels (dBW) at 3000 km\* for Interference which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	E	56.3	20.7	W	99.0	0.0
2	E	38.7	2.5	W	98.0	1.4
3	S	30.0	0.0	W	73.0	23.0
4	S	30.7	0.5	N	42.7	4.7
5	W	32.0	0.0	N	43.7	2.6
6	W	32.7	0.9	N	42.7	2.5
7	W	32.7	0.9	N	42.3	2.6
8	W	32.7	0.9	E	37.7	0.5
9	W	31.3	0.5	N	37.3	1.7
10	W	31.3	0.5	N	40.3	4.0
11	W	31.3	0.5	N	65.3	25.0
1	E S	75.2	24.4	N W	98.7	0.7
2	E S	43.3	12.1	N W	91.7	13.0
3	E S	34.0	4.1	N W	67.7	21.5
4	S W	34.0	4.9	N E	41.3	3.8
5	S W	32.5	0.8	N E	42.5	2.4
6	S W	33.0	0.8	N E	42.7	1.9
7	S W	33.5	1.1	N E	42.0	1.9
8	S W	33.7	1.2	N E	37.2	1.1
9	E W	33.2	2.0	N E	36.2	1.8
10	S W	32.5	1.3	N E	38.0	5.1
11	S W	31.7	0.7	N E	64.5	24.1
1	N E S	82.9	22.7	N S W	97.1	4.7
2	N E S	57.3	24.0	N S W	77.1	24.8
3	N E S	43.4	17.4	N E W	57.8	22.4
4	E S W	36.0	5.0	N E W	40.0	4.6
5	E S W	35.4	4.3	N E S	39.3	4.9
6	E S W	36.2	4.6	N E S	39.6	4.7
7	E S W	36.2	4.0	N E S	39.4	3.9
8	N S W	34.7	1.9	N E S	36.3	1.5
9	E S W	33.8	1.9	N E S	35.8	1.6
10	E S W	33.6	3.4	N E S	36.6	4.6
11	E S W	42.3	20.1	N E S	53.7	24.9
1	N E S W	86.9	20.9			
2	N E S W	67.5	27.2			
3	N E S W	50.8	22.9			
4	N E S W	37.7	5.7			
5	N E S W	37.5	5.3			
6	N E S W	37.8	5.0			
7	N E S W	37.8	4.5			
8	N E S W	35.4	2.1			
9	N E S W	34.7	2.4			
10	N E S W	35.3	4.6			
11	N E S W	48.1	23.6			

\* Centered on Boulder, Colorado

Table 7. Summary of Maximum and Minimum Mean Power Levels (dBW) at 4000 km\* for Interference which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	E	48.0	7.3	N	99.0	0.0
2	S	37.0	7.8	W	99.0	0.0
3	S	26.0	0.0	W	83.7	21.7
4	S	26.0	0.0	N	54.3	10.7
5	S	28.7	0.5	N	47.7	5.2
6	S	28.3	0.9	N	45.7	3.9
7	W	29.3	0.5	N	44.7	3.3
8	W	29.3	0.5	N	40.3	4.0
9	W	29.3	0.5	N	42.3	5.4
10	W	29.3	0.5	N	49.3	10.7
11	S	27.0	1.4	E	83.7	21.7
1	E S	73.2	5.7	N W	99.0	0.0
2	E S	38.2	5.6	N W	96.3	6.0
3	E S	32.2	6.4	N W	81.2	23.0
4	E S	33.0	7.2	N W	48.2	11.3
5	S W	29.3	1.2	N E	44.5	5.1
6	S W	28.8	0.9	N E	44.0	3.3
7	S W	29.5	0.5	N E	41.3	4.2
8	S W	29.8	0.7	N E	37.8	3.8
9	S W	30.2	1.3	N E	38.7	5.3
10	S W	29.8	0.7	N E	48.3	10.7
11	S W	28.2	1.6	N E	79.7	25.1
1	N E S	81.3	24.3	N S W	98.8	0.6
2	N E S	56.7	26.9	N E W	77.3	27.3
3	N E S	47.7	26.4	N E W	66.9	27.6
4	E S W	36.0	8.7	N E W	45.4	10.1
5	E S W	33.3	5.9	N E W	39.7	8.0
6	E S W	33.3	6.4	N E W	39.1	7.4
7	E S W	32.3	4.1	N E S	37.4	6.5
8	E S W	31.7	2.7	N E S	35.3	4.7
9	E S W	31.8	2.6	N E S	36.1	5.7
10	E S W	35.7	10.3	N E S	42.3	12.2
11	N S W	44.0	27.5	N E W	62.9	31.4
1	NESW	86.1	22.3			
2	NESW	67.3	29.7			
3	NESW	56.7	29.7			
4	NESW	40.6	12.1			
5	NESW	36.9	8.4			
6	NESW	36.4	8.0			
7	NESW	35.4	6.6			
8	NESW	33.8	4.9			
9	NESW	34.4	5.8			
10	NESW	39.1	12.0			
11	NESW	53.9	31.3			

\* Centered on Boulder, Colorado

Table 8. Summary of Maximum and Minimum Mean Power Levels (dBW) at 5000 km\* for Interference which is 90% Reliable at a S/N Ratio of 12 dB.

HOUR (UT)	BEARING	MINIMUM POWER (DBW)	STND DEV.	BEARING	MAXIMUM POWER (DBW)	STND DEV.
1	E	52.0	4.5	N	99.0	0.0
2	S	42.0	7.5	W	99.0	0.0
3	S	31.3	0.5	W	94.0	7.1
4	S	31.3	0.5	W	66.3	11.1
5	S	31.3	0.5	N	59.0	10.7
6	S	31.3	0.5	N	56.3	9.5
7	S	32.0	0.8	N	55.7	9.5
8	S	32.0	0.8	N	53.7	10.3
9	W	32.3	0.5	N	55.7	11.1
10	W	32.3	0.5	E	62.3	8.2
11	S	31.3	1.2	N	94.3	6.6
1	N E	75.5	23.7	N S	99.0	0.0
2	E S	43.3	5.6	N W	98.0	2.2
3	E S	36.3	5.2	N W	86.2	17.4
4	E S	36.3	5.2	N W	64.5	12.5
5	S W	36.5	6.8	N E	50.7	11.4
6	S W	32.5	1.4	N E	48.8	10.2
7	S W	32.8	1.2	N E	47.5	10.6
8	S W	32.8	1.2	N E	45.5	10.9
9	S W	32.5	1.3	N E	49.5	10.3
10	S W	32.3	0.9	N E	61.2	11.0
11	S W	31.8	1.1	N E	94.0	7.1
1	N E S	83.3	22.3	N S W	99.0	0.0
2	N E S	61.2	25.8	N E W	80.2	25.2
3	N E S	50.3	23.5	N E W	71.2	25.5
4	N E S	45.1	15.2	N E W	56.8	15.0
5	E S W	38.4	6.3	N E W	47.7	10.8
6	E S W	35.4	4.5	N E W	43.8	11.0
7	E S W	35.0	3.3	N E W	42.9	10.8
8	E S W	34.3	2.4	N E W	41.6	10.5
9	E S W	36.1	5.6	N E S	43.9	11.6
10	N S W	41.6	15.1	N E S	51.6	16.3
11	E S W	52.4	29.5	N E W	73.4	29.6
1	NESW	87.3	20.5			
2	NESW	70.7	27.7			
3	NESW	61.3	28.0			
4	NESW	50.4	17.0			
5	NESW	43.6	11.7			
6	NESW	40.7	11.0			
7	NESW	40.2	10.5			
8	NESW	39.2	10.0			
9	NESW	41.0	11.2			
10	NESW	46.8	16.4			
11	NESW	62.9	31.5			

\* Centered on Boulder, Colorado

Table 9. Estimated Transmitter Mean Nighttime Power Required to Produce a Threshold CW Signal in a 100-Hz Bandwidth With 90% Reliability.

Range (km)	April				May				June			
	N	E	S	W	N	E	S	W	N	E	S	W
500	13	17	13	14	13	16	13	13	20	23	15	17
1000	12	16	11	11	11	17	11	10	20	23	09	11
2000	27	23	14	13	22	24	14	12	26	28	12	13
3000	26	27	21	20	30	27	21	21	30	27	21	21
4000	29	27	16	21	31	28	16	19	43	28	19	20
5000	33	31	20	24	44	33	20	26	60	34	21	23

## 6. POTENTIAL INTERFERENCE

The remaining task is to compare location and power of station allocations operating at a frequency of 2.666 MHz with the calculated interference power. The 2.666-MHz frequency assignments were obtained from IFRB (1969) and Telecommunication Management (1969). Table 10 lists 27 transmitting stations identified by bearing and distance from Boulder, Colorado, and figure 7 shows a plot of these same potential interfering sources. Where the two information sources have conflicting allocated transmitter power, both are listed. The type of modulation and the hours of operation are not considered in this report, since varying degrees of interference are expected with different types of modulation schemes and at different times of day.

The experimental transmitter site at Sunset, Colorado (KC2XML) was omitted because of its extremely high pulse power, its intermittent operation, and its proximity to the receiver site. For short ground ranges, multipath interference becomes of prime concern, since the ionosphere is capable of multiple mode support and since the sky-wave

Table 10. Radio Station Assignments for 2.666 MHz

Location Relative to Boulder, Colorado			Transmitting Station	
Bearing (Deg.)	Distance (km)	Power (kW)	Name	Call Ident.
308°	1783	0.03	Pt. Renfrew, B.C., Canada	CJW236
71°	2168	0.30	Toronto, Ontario, Canada	CIT
109°	2411	* 1.00	Jacksonville, Fla.	NMV
117°	2487	* 1.00	St. Petersburg, Fla.	NOF
320°	2625	{ 0.50 * 1.00 }	Ketchikan, Alaska	NMJ
66°	2639	0.30	Montreal, P.Q., Canada	CIZ
117°	2824	1.00	Miami, Fla.	NMA
324°	2887	{ 0.50 * 1.00 }	Juneau, Alaska	NMJ1
66°	3174	0.03	Frederiction, N.B., Canada	CIX6
67°	3221	0.03	St. John, N.B., Canada	CIX3
64°	3440	0.30	Charlottet, Pei, Canada	CIX
51°	3646	0.10	Otter Ck., NFLD, Canada	XXM39
59°	3813	0.08	Conner BRK, NFL, Canada	XXM26
316°	3921	* 3.00	Kodiak, Alaska	NOJ
314°	3940	* 1.00	Sitkinak, Alaska	NRW1
55°	3967	0.08	St. Anthony, NFLD, Canada	XXM53
59°	4057	0.08	Gander, NFLD, Canada	XXM49
61°	4213	0.08	St. Johns, NFLD, Canada	XXM67
111°	4441	{ 0.5 * 1.0 }	San Juan, Puerto Rico	NMR
311°	4616	* 1.0	Cape Sarichef, Alaska	NRW
327°	4727	* 1.0	Pt. Clarence, Alaska	NRW3
315°	4928	* 1.0	St. Paul, Alaska	NRW2
309°	5432	* 1.0	Adak Lorsta, Alaska	NMJ
313°	6060	{ 0.5 * 1.0 }	Attu, Alaska	NMJ22
32°	7471	0.02	Kristiansands, Norway	LBD
38°	7768	0.25	Hilversum, Netherlands	PEP2
9°	7894	1.00	Narian Mar, Soviet Union	RLQ6

\* Telecommunication Management (1969)

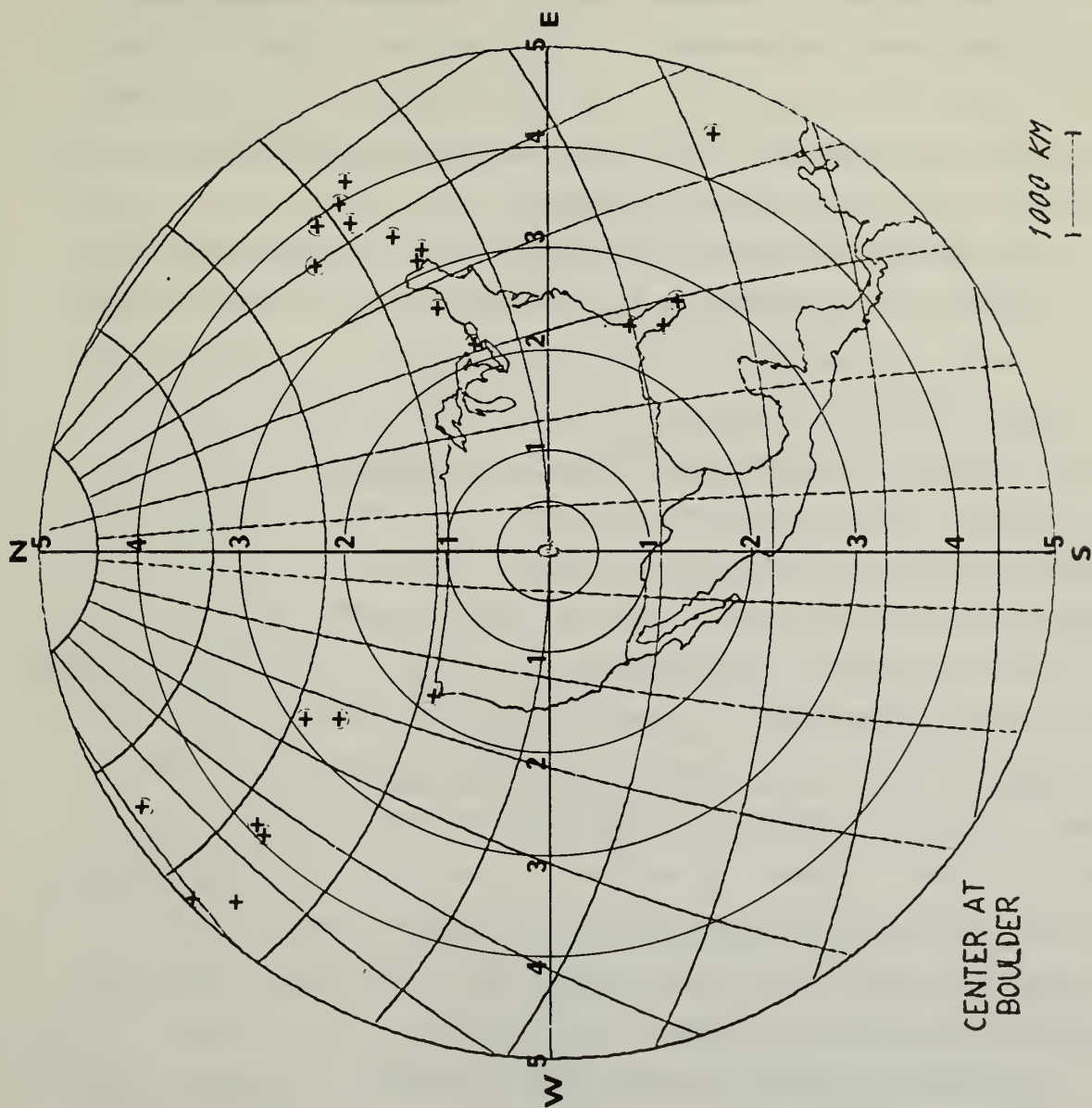


Figure 7. Range and bearing of allocated station assignments on 2.666 MHz.

versus ground-wave field strengths present interference possibilities. Two additional roving allocations were also omitted because their exact location is unknown; one station was confined to the state of Alaska, and the other to the 48 contiguous states.

A high degree of correlation would be expected between the ionospheric control points chosen by the computer program and the sun's position, since the latter is the principal hourly variable, and it is verified by the hourly shift of the maximum and minimum required power noted for the various path lengths.

The minimum transmitter antenna input power required for 90 percent reliability at Boulder from a distance of 500 km was received from a south bearing for 10 of the 11 hours calculated. Increasing the distance to 1000 km showed an equal distribution of minimum required transmitting power between south and west bearings. Increasing the path length to 2000 km showed an increase of the west bearings to a total of 6 hours, with the south bearing reduced to 4 hours and only a single east bearing indicated. For the 3000-km path, the west bearing continued to increase to its maximum of 7 hours, with the south bearing decreasing to its minimum of 2 hours. The maximum number of east bearings showing a value of minimum required power was 2 in the 11 hours calculated for the 3000-km path. As expected, of the four bearings being compared, no northerly paths of any length for any hour calculated showed the lowest required transmitter power for 90 percent reliability. Extending the path length to 4000 km reversed the favored bearing to the south for 6 hours, with 4 hours of west bearings indicated.

As shown in tables 3 through 8, the maximum transmitter antenna input power required for 90 percent reliability at the Boulder receiver displays a shift from a predominantly east bearing at 500 km to a

predominantly north bearing for path lengths greater than 2000 km. The west bearing for a total of 3 hours displayed the highest required transmitter power for the 3000-km path.

An interesting detail about the occurrence of the minimum standard deviation as a function of distance is apparent in these tables. For path lengths of 500 and 1000 km, the smallest variability is indicated at 8 UT, shifting to 9 UT for 2000 km, and to 10 UT for 3000, 4000, and 5000 km.

The arrival angle statistics given in appendix C as a function of hour and month may prove important to antenna studies for the suppression of interference. The arrival angle's standard deviation indicates whether the mode is changing and/or the possibility of multipath.

## 7. SUMMARY AND CONCLUSIONS

The ITS ionospheric computer prediction model was used for estimating the transmitter power required to produce a uniform 100-Hz bandwidth CW signal via the dominant mode that is 90 percent reliable at the Boulder site. These estimates indicate the potential interference, either accidental or deliberate, that may arrive via sky-wave signals from distant transmitters operating on the same frequency.

In summary, the results of this study are as follows:

- (1) Further measurements at other distances and bearings over an extended time period are required for a better determination of computational accuracy.
- (2) The 2.666-MHz transmissions from Long Branch, Illinois, during the nighttime were consistently received at Table Mountain.
- (3) Relatively few consistent and/or strong additional signals were recorded over the 1000-Hz band monitored despite the large number of allocations.

(4) The predicted median field strengths were 8 dB lower than the medians of limited observations on a 1288-km east-west path. Good general agreement in diurnal shape was observed, as shown in figure 6.

(5) The estimated transmitter mean nighttime power required to produce a threshold CW signal with 90 percent reliability at the Boulder site, is based on an assumed 8-dB correction at all distances. The summary of transmitter power values (dBW) are given in table 9.

(6) From table 9, we can conclude that it would be relatively easy to cause significant interference from as far away as 5000 km.

## 8. ACKNOWLEDGMENTS

This report is the result of a coordinated effort of many groups and individuals within ITS, ESSA Research Laboratories. In particular, the authors wish to acknowledge the helpful suggestions and encouragement of Mr. Alfred F. Barghausen in the preparation of this report; Mr. J. W. Finney and Mr. R. K. Rosich for their consultative advice and assistance; and Mr. Gary D. Gierhart and Mr. Garth H. Stonehocker for their critical review of the manuscript;

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<sup>1</sup> This document is in the public domain, but is considered unpublished since it was not printed for wide public distribution.



## APPENDIX A

### Signal-to-Noise Ratios Required for Satisfactory Service

# Signal-to-Noise Ratios Required for Satisfactory Service

Required Signal-to-Noise Ratio in Occupied Bandwidth  
Relative to Noise in a 1-Hz Bandwidth (dB)

Radio Telephone	Grade of Service					
Description	Operator-to-Operator <sup>(1)</sup>			Good Commercial Quality		
	Stable Condition	Fading Condition		Stable Condition	Fading Condition	
		No Diversity	Dual Diversity		No Diversity	Dual Diversity
6A3 Double Sideband - AM	50	51	48	67	75	70
3A3 Single Sideband - AM						
3A3a (reduced carrier)	48	49	46	65	73	68
3A3j (suppressed carrier)	47	48	45	64	72	67
6A3 Independent Sideband - AM						
6A3b (2-voice channels)	49	50	47	66	74	69
9A3b (3-voice channels)	49	50	47	66	74	69
12A3b (4-voice channels)	50	51	48	67	75	70

(1) For 90 percent intelligibility of related words.

Required Signal-to-Noise Ratio in Occupied Bandwidth  
Relative to Noise in a 1-Hz Bandwidth (dB)

Radio Teletype Description	Grade of Service							
	Character Error Rate (1)							
	10 <sup>-2</sup>		10 <sup>-3</sup>		10 <sup>-4</sup>			
	No Diversity	Dual Diversity	No Diversity	Dual Diversity	No Diversity	Dual Diversity	No Diversity	Dual Diversity
1.1F1 FSK, 60 WPM, 1500-Hz filter Start-Stop Synchronous	56 51	51 47	63 59	59 55	69 66	64 61		
3A7j SSB, suppressed carrier, 16- teletype subchannels, each sub- channel $\pm 42.5$ Hz FSK, 110-Hz filter, 100 WPM, 5-unit								
6A9b (2) ISB, 1-voice channel and 16- teletype subchannels, each subchannel $\pm 42.5$ Hz, FSK, 110-Hz filter, 100 WPM	62 57	59 53	69 65	65 61	75 72	70 67		
12A9b (2) ISB, 2-voice channels and 32- teletype subchannels, each subchannel $\pm 42.5$ Hz, FSK, 110-Hz filter, 100 WPM	65 60	60 56	72 68	66 64	78 75	71 70		
Start-Stop Synchronous								
Start-Stop Synchronous	66 61	62 57	73 69	68 65	79 76	73 71		

(1) - 5-unit code, no error control schemes.

(2) - Power assumed equally divided between channels.



## APPENDIX B

### "HF MUFES2" Long Branch-to-Boulder Prediction Estimates

A description of the circuit parameters used in the calculations of the system performance predictions is shown in the heading for each hour of data. This appendix shows on each sheet four computer printed pages in a single modified and reduced form. Starting at the top of the page, this heading is as follows:

The first line contains the month, day, and year, and the solar activity level as indicated by the 10-cm flux and the 12-month running average Zurich sunspot number. The second and third lines contain the name and coordinates of the transmitter and receiver locations, the azimuthal bearings in degrees of the receiver from the transmitter and vice versa, and the length of the circuit in statute miles and kilometers. The minimum angle on the fourth line indicates the lowest vertical angle considered in the mode selection process. The fifth and sixth lines describe the frequency range (2 to 30 MHz), the antenna type, the physical parameters of the antenna system for each terminal, and the orientation of the antenna's main beam relative to the great-circle path.

The seventh line contains the power output of the transmitter; the man-made noise level assumed for the receiver location, in decibels relative to 1 watt in a 1-Hz bandwidth at a frequency of 3 MHz; the time availability for service probability calculations; and the hourly median signal-to-noise ratio required to provide the type of service requested.

The first line of each time block gives the universal time (UT) in hours followed by the complete tabulation of all quantities used in the calculations for each hour. The first parameters listed under "Reflection Area Data" are those associated with the five reflection areas considered for each path. Reflection area data 1 is used for path lengths less than or equal to 2000 km; 2, 3, and 4 are used for path lengths between 2000 and 4000 km; and 1, 2, 3, 4, and 5 are used for path lengths greater than or equal to 4000 km.

For each reflection area, the following parameters are listed (if zero appears, the parameters are not calculated):

- (a) Distance from transmitter in kilometers.
- (b) Geographic latitude in degrees.
- (c) Geographic longitude in degrees.
- (d) Geomagnetic latitude in degrees.
- (e) Local time at the reflection area.
- (f) Absorption factor (see sec. 7.2 of Barghausen et al., 1969).
- (g) E-layer critical frequency in MHz.
- (h) Virtual height of the F-layer's lower limit in km.
- (i) Gyrofrequency in MHz.
- (j) F-layer critical frequency in MHz.
- (k) fEs sporadic-E median critical frequency in MHz.

The parameters for the specific circuit determined from the above values at the various reflection areas are then listed as follows:

- (a) Local time at the receiver.
- (b) Absorption factor.
- (c) E-layer critical frequency in MHz.
- (d) Gyrofrequency at E-layer height in MHz.
- (e) Height of the F-layer's maximum in km.
- (f) Semithickness of the F layer in km.
- (g) F-layer critical frequency in MHz.
- (h) MUF (maximum usable frequency) in MHz
- (i) FOT (optimum traffic frequency) in MHz.
- (j) HPF (highest possible frequency) in MHz.
- (k) Excess system loss in decibels.
- (l) The 50 percent value of fEs in MHz.
- (m) The 90 percent value of fEs in MHz.
- (n) The 10 percent value of fEs in MHz.
- (o) Adjusted MUF for K indices from 0 to 9.

The adjusted MUF is an estimate of the modified MUF due to magnetic activity, specifically the MUF for a local magnetic K index of 0 through 9. The remaining two blocks of data are frequency dependent. The first block is calculated for the MUF frequency and the second for the desired 2.666-MHz frequency. For each frequency the following items associated with the median noise power in a 1-Hz bandwidth at the receiving location in decibels relative to  $kT_0b$  are listed: (1) Atmospheric noise; (2) galactic noise; (3) man-made noise; (4) a value in decibels used to adjust the controlling noise when two or more types of noise are nearly the same value; (5) the efficiency, expressed in decibels, of the receiving antenna; (6) the controlling noise at the receiving antenna site. The value of  $k$  (Boltzmann's constant) is  $1.38 \times 10^{-23}$  joules per degree Kelvin, the reference temperature  $T_0$  is  $288^\circ$  K,  $10 \log_{10} kT_0 = -204$  dB relative to one joule (1 w/Hz), and  $b$  is the bandwidth in Hz.

The following parameters for each of seven modes are considered, i. e., two E modes, three F modes, and two mixed modes (mixed modes are computed only if the path length is equal to or greater than 3000 km):

- (a) Number of hops.
- (b) Vertical angle in degrees.
- (c) Virtual height in kilometers.
- (d) Time delay in milliseconds.
- (e) Free-space loss in decibels.
- (f) Absorption loss in decibels.
- (g) Ground reflection loss in decibels.
- (h) Transmitting antenna gain in decibels relative to an isotropic source.
- (i) Receiving antenna gain in decibels relative to an isotropic source.
- (j) Median monthly transmission loss in decibels.

- (k) Median monthly incident field strength in decibels relative to 1  $\mu\text{V/m}$ .
- (l) Median monthly signal power in decibels relative to 1 watt.
- (m) Signal-to-noise ratio in decibels.
- (n) Fraction of days during the month for the indicated hour the sky wave is expected to exist.
- (o) Fraction of days during the month for the indicated hour that the required signal-to-noise ratio will be equaled or exceeded.
- (p) Reliability.
- (q) Service probability.

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
40.30N - 90.06M 40.11N 105.24W 273.98 84.15 800.2 1287.8  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.008

UT = 02

REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	19.489	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
E-LAYER CRITICAL	1.207	0.000	0.000	0.000
F-LAYER BOTTOM	257.155	0.000	0.000	0.000
HEIGHT OF FMAX	331.739	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	8.326	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 18.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 1.21  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 331.33 SEMI-THICKNESS 74.58  
F-LAYER CRITICAL 8.33 MUF 14.93 FOT 12.24 HPF 17.02  
EXCESS SYS LOSS 11.10 ESM 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
16.68 15.76 14.84 13.92 13.00 12.08 11.16 10.24 9.32 9.40

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-170.59 -181.34 -162.60 0.00 -0.57 -163.17  
E-MODES F-MODES EF-MODES

1	2	3	4	5
NUMBER OF HOPS	1	2	1	2
TAKE-OFF ANGLE	0.00	0.00	26.54	48.98
VIRTUAL HEIGHT	0.00	0.00	373.93	401.61
TIME DELAY IN MS	-	-	5.07	-
SKY WAVE LOSS	-	-	119.57	-
ABSORPTION LOSS	-	-	0.03	-
GROUND REF. LOSS	-	-	0.00	-
XMTX ANT. GAIN	-	-	2.83	-
RCVR ANT. GAIN	-	-	-0.90	-
TRANSMISSION LOS	-	-	128.77	-
FIELD STRENGTH	-	-	33.60	-
SIGNAL POWER	-	-	-97.97	-
S/N IN OB	-	-	64.50	-
FRACTION OF DAYS	-	-	0.50	-
FRACTION OF S/N	-	-	0.93	-
RELIABILITY	-	-	0.46	-
SERVICE PROBABLE	-	-	0.39	-

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-149.29 -204.00 -147.09 1.00 -0.57 -146.67  
E-MODES F-MODES EF-MODES

1	2	3	4	5
NUMBER OF HOPS	1	2	2	3
TAKE-OFF ANGLE	5.33	16.09	38.05	49.73
VIRTUAL HEIGHT	93.81	102.60	260.08	261.55
TIME DELAY IN MS	4.37	4.54	5.68	6.92
SKY WAVE LOSS	103.31	103.65	105.58	107.30
ABSORPTION LOSS	0.71	0.86	0.44	0.54
GROUND REF. LOSS	0.00	4.10	5.21	10.65
XMTX ANT. GAIN	-10.00	-7.43	-1.84	-1.17
RCVR ANT. GAIN	127.56	1.01	0.07	-1.84
TRANSMISSION LOS	121.68	126.12	124.11	132.55
FIELD STRENGTH	21.39	19.37	22.33	15.80
SIGNAL POWER	-96.89	-95.33	-93.32	-101.76
S/N IN OB	48.98	50.54	52.55	44.11
FRACTION OF DAYS	0.99	0.99	0.99	0.99
FRACTION OF S/N	0.75	0.78	0.81	0.63
RELIABILITY	0.74	0.77	0.81	0.63
SERVICE PROBABLE	0.00	0.01	0.04	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
40.30N - 90.06M 40.11N 105.24W 273.98 84.15 800.2 1287.8  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.008

UT = 01

REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	18.489	0.000	0.000	0.000
ABSORP. FACTOR	0.256	0.000	0.000	0.000
E-LAYER CRITICAL	1.722	0.000	0.000	0.000
F-LAYER BOTTOM	251.447	0.000	0.000	0.000
HEIGHT OF FMAX	326.155	0.000	0.000	0.000
GYRO-FREQUENCY	1.372	0.000	0.000	0.000
F-LAYER CRITICAL	9.152	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 17.98 ABSORP. FACTOR 0.26 E-LAYER CRITICAL 1.72  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 325.45 SEMI-THICKNESS 74.71  
F-LAYER CRITICAL 9.15 MUF 16.58 FOT 13.60 HPF 18.91  
EXCESS SYS LOSS 11.70 ESM 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
18.54 17.51 16.49 15.47 14.44 13.42 12.40 11.37 10.35 9.33

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-170.59 -181.34 -162.60 0.00 -0.57 -163.17  
E-MODES F-MODES EF-MODES

1	2	3	4	5
NUMBER OF HOPS	1	2	1	2
TAKE-OFF ANGLE	0.00	0.00	26.11	48.33
VIRTUAL HEIGHT	0.00	0.00	366.76	391.90
TIME DELAY IN MS	-	-	5.05	-
SKY WAVE LOSS	-	-	120.45	-
ABSORPTION LOSS	-	-	0.63	-
GROUND REF. LOSS	-	-	0.00	-
XMTX ANT. GAIN	-	-	2.71	-
RCVR ANT. GAIN	-	-	-0.98	-
TRANSMISSION LOS	-	-	131.04	-
FIELD STRENGTH	-	-	32.32	-
SIGNAL POWER	-	-	-100.25	-
S/N IN OB	-	-	62.92	-
FRACTION OF DAYS	-	-	0.50	-
FRACTION OF S/N	-	-	0.88	-
RELIABILITY	-	-	0.44	-
SERVICE PROBABLE	-	-	0.15	-

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-152.56 -204.00 -147.09 1.00 -0.57 -146.67  
E-MODES F-MODES EF-MODES

1	2	3	4	5
NUMBER OF HOPS	1	2	2	3
TAKE-OFF ANGLE	5.15	14.84	39.92	50.25
VIRTUAL HEIGHT	91.77	94.79	253.97	254.81
TIME DELAY IN MS	4.37	4.51	5.82	6.98
SKY WAVE LOSS	103.31	103.58	105.80	107.39
ABSORPTION LOSS	18.26	23.33	10.93	13.83
GROUND REF. LOSS	0.00	3.94	5.23	10.66
XMTX ANT. GAIN	-10.00	-8.07	-1.65	-1.18
RCVR ANT. GAIN	-2.72	0.89	0.18	-1.95
TRANSMISSION LOS	145.99	149.73	135.50	146.62
FIELD STRENGTH	3.24	-4.11	11.19	1.83
SIGNAL POWER	-115.20	-118.94	-104.71	-115.83
S/N IN OB	31.47	27.72	41.96	30.83
FRACTION OF DAYS	0.99	0.99	0.99	0.99
FRACTION OF S/N	0.18	0.04	0.56	0.16
RELIABILITY	0.18	0.04	0.55	0.16
SERVICE PROBABLE	0.00	0.00	0.00	0.00

APRIL 15, 1969 10 CM FLUX 154 (ISSN 106)  
HAWAII, ILL. TO BOULDER, COLO.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
MINIMUM ANGLE 0.0 DEGREES  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KM 3 MHZ NOISE=-148.608B TIME= 90 PERCENT REQ.S/N=40.00B

UT = 03

REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	20.449	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
F-LAYER CRITICAL	0.840	0.000	0.000	0.000
F-LAYER BOTTOM	264.088	0.000	0.000	0.000
HEIGHT OF PHAX	346.204	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	7.448	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 19.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.84  
GYRO-FREQUENCY 1.54 HEIGHT OF PHAX 345.96 SEMI-THICKNESS 82.12  
F-LAYER CRITICAL 7.45 MUF 12.94 FOT 10.61 HPF 14.75  
EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9

14.46 13.66 12.86 12.07 11.27 10.47 9.67 8.87 8.07 7.28

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-165.87 -178.96 -163.31 1.80 -0.57 -162.08  
F-MODES E-MODES EF-MODES

1	2	1	2	3	0
NUMBER OF HOPS	0.00	0.00	27.61	50.46	63.44
TAKE-OFF ANGLE	0.00	0.00	391.02	424.28	464.28
VIRTUAL HEIGHT	-	-	5.14	-	-
TIME DELAY IN MS	-	-	118.44	-	-
SKY WAVE LOSS	-	-	0.04	-	-
ABSORPTION LOSS	-	-	0.00	-	-
GROUND REF. LOSS	-	-	1.30	-	-
XMTX ANT. GAIN	-	-	-0.78	-	-
RCVR ANT. GAIN	-	-	129.05	-	-
TRANSMISSION LOS	-	-	31.96	-	-
FIELD STRENGTH	-	-	-98.25	-	-
SIGNAL POWER	-	-	63.83	-	-
S/N IN DB	-	-	0.50	-	-
FRACTION OF DAYS	-	-	0.92	-	-
FRACTION OF S/N	-	-	0.46	-	-
RELIABILITY	-	-	0.36	-	-
SERVICE PROBABLE	-	-	-	-	-

FREQUENCY = 12.936 MHZ  
NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-146.07 -208.00 -147.09 1.80 -0.57 -144.84  
F-MODES E-MODES EF-MODES

1	2	1	2	3	0
NUMBER OF HOPS	5.79	0.00	20.40	38.21	50.28
TAKE-OFF ANGLE	99.19	0.00	265.92	268.47	270.54
VIRTUAL HEIGHT	4.38	-	4.77	5.69	7.01
TIME DELAY IN MS	103.33	-	104.07	105.61	107.41
SKY WAVE LOSS	0.69	-	0.36	0.44	0.54
ABSORPTION LOSS	-	-	0.00	5.21	10.66
GROUND REF. LOSS	-	-	0.00	-1.82	-1.10
XMTX ANT. GAIN	-10.00	-	-5.63	-1.22	-1.95
RCVR ANT. GAIN	-2.16	-	1.22	0.05	-1.95
TRANSMISSION LOS	127.28	-	119.95	124.14	132.77
FIELD STRENGTH	21.39	-	25.35	22.32	15.70
SIGNAL POWER	-96.49	-	-89.15	-93.35	-101.97
S/N IN DB	48.35	-	55.69	51.49	42.87
FRACTION OF DAYS	0.99	-	0.99	0.99	0.99
FRACTION OF S/N	0.71	-	0.83	0.77	0.58
RELIABILITY	0.70	-	0.82	0.76	0.58
SERVICE PROBABLE	0.00	-	0.11	0.02	0.00

APRIL 15, 1969 10 CM FLUX 154 (ISSN 106)  
HAWAII, ILL. TO BOULDER, COLO.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
MINIMUM ANGLE 0.0 DEGREES  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KM 3 MHZ NOISE=-148.608B TIME= 90 PERCENT REQ.S/N=40.00B

UT = 04

REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	21.449	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
F-LAYER CRITICAL	0.840	0.000	0.000	0.000
F-LAYER BOTTOM	277.375	0.000	0.000	0.000
HEIGHT OF PHAX	362.113	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	6.709	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 20.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.64  
GYRO-FREQUENCY 1.54 HEIGHT OF PHAX 361.94 SEMI-THICKNESS 84.74  
F-LAYER CRITICAL 6.71 MUF 11.32 FOT 9.28 HPF 12.90  
EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9

12.72 12.07 11.42 10.78 10.13 9.48 8.84 8.19 7.54 6.90

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-162.75 -177.69 -163.69 1.80 -0.57 -161.53  
F-MODES E-MODES EF-MODES

1	2	1	2	3	0
NUMBER OF HOPS	0.00	0.00	28.80	51.82	64.44
TAKE-OFF ANGLE	0.00	0.00	410.54	445.53	486.68
VIRTUAL HEIGHT	-	-	5.21	7.43	-
TIME DELAY IN MS	-	-	117.40	120.49	-
SKY WAVE LOSS	-	-	0.04	0.06	-
ABSORPTION LOSS	-	-	0.00	8.65	-
GROUND REF. LOSS	-	-	1.24	-10.00	-
XMTX ANT. GAIN	-	-	-0.67	-3.43	-
RCVR ANT. GAIN	-	-	127.97	153.73	-
TRANSMISSION LOS	-	-	31.77	9.78	-
FIELD STRENGTH	-	-	-97.18	-122.93	-
SIGNAL POWER	-	-	64.35	38.59	-
S/N IN DB	-	-	0.50	0.00	-
FRACTION OF DAYS	-	-	0.93	0.45	-
FRACTION OF S/N	-	-	0.46	0.00	-
RELIABILITY	-	-	0.39	0.00	-
SERVICE PROBABLE	-	-	-	-	-

FREQUENCY = 2.666 MHZ  
NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-142.86 -208.00 -147.09 1.80 -0.57 -142.43  
F-MODES E-MODES EF-MODES

1	2	1	2	3	0
NUMBER OF HOPS	7.31	0.00	20.68	39.49	51.68
TAKE-OFF ANGLE	117.05	0.00	279.86	283.37	286.15
VIRTUAL HEIGHT	4.40	-	4.78	5.81	7.24
TIME DELAY IN MS	103.38	-	104.10	105.79	107.69
SKY WAVE LOSS	0.65	-	0.36	0.43	0.53
ABSORPTION LOSS	-	-	0.00	5.23	10.67
GROUND REF. LOSS	-	-	0.00	-1.69	-1.09
XMTX ANT. GAIN	-10.00	-	-5.54	-1.22	-2.25
RCVR ANT. GAIN	-1.16	-	1.22	0.12	-2.25
TRANSMISSION LOS	126.28	-	119.88	124.36	133.33
FIELD STRENGTH	21.38	-	25.41	22.27	15.43
SIGNAL POWER	-95.49	-	-89.08	-93.57	-102.54
S/N IN DB	46.94	-	53.35	48.86	39.89
FRACTION OF DAYS	0.99	-	0.99	0.99	0.99
FRACTION OF S/N	0.69	-	0.81	0.73	0.50
RELIABILITY	0.68	-	0.80	0.72	0.49
SERVICE PROBABLE	0.00	-	0.06	0.01	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.90 84.15 800.2 1287.8  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608M TIME= 90 PERCENT REQ.S/N=40.008

UT = 05

# REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	22.489	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
E-LAYER CRITICAL	0.556	0.000	0.000	0.000
F-LAYER BOTTOM	294.174	0.000	0.000	0.000
HEIGHT OF FMAX	371.982	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	6.187	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 21.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.56  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 371.83 SEMI-THICKNESS 77.81  
 F-LAYER CRITICAL 6.19 MUF 10.32 FOT 8.16 HPF 11.87  
 EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 11.60 11.01 10.42 9.83 9.24 8.65 8.06 7.47 6.88 6.29

# FREQUENCY = 10.323 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-160.08	-176.81	-163.96	1.00	-0.57	-159.65
E-MODES	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	29.60	52.32	64.55
VIRTUAL HEIGHT	0.00	0.00	423.90	455.07	489.43
TIME DELAY IN MS	-	-	5.26	-	-
SKY WAVE LOSS	-	-	116.68	-	-
ABSORPTION LOSS	-	-	0.05	-	-
GROUND REF. LOSS	-	-	0.00	-	-
XMTX ANT. GAIN	-	-	2.39	-	-
RCVR ANT. GAIN	-	-	-0.60	-	-
TRANSMISSION LOS	-	-	126.04	-	-
FIELD STRENGTH	-	-	32.82	-	-
SIGNAL POWER	-	-	-95.25	-	-
S/N IN OB	-	-	64.40	-	-
FRACTION OF DAYS	-	-	0.50	-	-
RELIABILITY	-	-	0.96	-	-
SERVICE PROBABLE	-	-	0.48	-	-

# FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-139.78	-204.00	-147.09	0.00	-0.57	-140.35
E-MODES	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	21.71	41.11	53.27
VIRTUAL HEIGHT	0.00	0.00	297.12	301.16	304.17
TIME DELAY IN MS	-	-	4.83	5.97	7.52
SKY WAVE LOSS	-	-	104.18	106.02	108.03
ABSORPTION LOSS	-	-	0.35	0.42	0.52
GROUND REF. LOSS	-	-	5.25	10.69	-
XMTX ANT. GAIN	-	-	-0.18	-1.55	-1.09
RCVR ANT. GAIN	-	-	1.23	-0.35	-2.60
TRANSMISSION LOS	-	-	119.59	124.68	134.02
FIELD STRENGTH	-	-	25.70	22.17	15.09
SIGNAL POWER	-	-	-88.80	-93.89	-103.23
S/N IN OB	-	-	51.55	46.46	37.12
FRACTION OF DAYS	-	-	0.99	0.99	0.99
RELIABILITY	-	-	0.82	0.71	0.39
SERVICE PROBABLE	-	-	0.62	0.70	0.39

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.90 84.15 800.2 1287.8  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608M TIME= 90 PERCENT REQ.S/N=40.008

UT = 06

# REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	23.489	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
E-LAYER CRITICAL	0.528	0.000	0.000	0.000
F-LAYER BOTTOM	305.016	0.000	0.000	0.000
HEIGHT OF FMAX	374.473	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	5.875	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 22.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.53  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 374.32 SEMI-THICKNESS 69.46  
 F-LAYER CRITICAL 5.87 MUF 9.83 FOT 7.76 HPF 11.30  
 EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 11.04 10.48 9.92 9.35 8.79 8.23 7.67 7.11 6.55 5.99

# FREQUENCY = 9.826 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-156.26	-176.34	-163.75 <td>1.00</td> <td>-0.57</td> <td>-157.83</td>	1.00	-0.57	-157.83
E-MODES	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	29.72	52.41	64.21
VIRTUAL HEIGHT	0.00	0.00	425.93	456.64	481.42
TIME DELAY IN MS	-	-	5.27	-	-
SKY WAVE LOSS	-	-	116.27	-	-
ABSORPTION LOSS	-	-	0.05	-	-
GROUND REF. LOSS	-	-	0.00	-	-
XMTX ANT. GAIN	-	-	3.28	-	-
RCVR ANT. GAIN	-	-	-0.55	-	-
TRANSMISSION LOS	-	-	124.69	-	-
FIELD STRENGTH	-	-	33.70	-	-
SIGNAL POWER	-	-	-93.90	-	-
S/N IN OB	-	-	63.94	-	-
FRACTION OF DAYS	-	-	0.50	-	-
RELIABILITY	-	-	0.96	-	-
SERVICE PROBABLE	-	-	0.48	-	-

# FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-137.71	-204.00	-147.09	0.00	-0.57	-138.28
E-MODES	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	22.42	42.09	54.20
VIRTUAL HEIGHT	0.00	0.00	308.09	312.23	315.21
TIME DELAY IN MS	-	-	4.86	6.07	7.71
SKY WAVE LOSS	-	-	104.24	106.17	108.24
ABSORPTION LOSS	-	-	0.34	0.41	0.51
GROUND REF. LOSS	-	-	5.26	10.69	-
XMTX ANT. GAIN	-	-	-4.96	-1.47	-1.09
RCVR ANT. GAIN	-	-	1.22	-0.50	-2.81
TRANSMISSION LOS	-	-	119.41	124.90	134.45
FIELD STRENGTH	-	-	25.87	22.10	14.87
SIGNAL POWER	-	-	-88.62	-94.11	-103.66
S/N IN OB	-	-	49.66	44.17	36.52
FRACTION OF DAYS	-	-	0.99	0.99	0.99
RELIABILITY	-	-	0.78	0.84	0.29
SERVICE PROBABLE	-	-	0.06	0.00	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.6  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.008

UT = 06

# REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.344	40.454	40.454
LONGITUDE	97.661	97.661	97.661	97.661
GEOMAGNETIC LAT	50.258	50.258	50.258	50.258
TIME IN HOURS	0.489	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
E-LAYER CRITICAL	0.508	0.000	0.000	0.000
F-LAYER BOTTOM	306.600	0.000	0.000	0.000
HEIGHT OF FMAX	374.373	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	5.706	0.000	0.000	0.000
ES MEAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 23.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.51  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 374.22 SEMI-THICKNESS 67.77  
 F-LAYER CRITICAL 5.71 HUF 9.56 FOT 7.55 HPF 10.99  
 EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56

# NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
NUMBER OF HOPS	1	2	3	0
TAKE-OFF ANGLE	0.00	0.00	29.83	52.57
VIRTUAL HEIGHT	0.00	0.00	427.81	459.37
TIME DELAY IN MS	-	-	5.27	4.74
SKY WAVE LOSS	-	-	116.02	-
ABSORPTION LOSS	-	-	0.06	-
GROUND REF. LOSS	-	-	0.00	-
XMTX ANT. GAIN	-	-	3.81	-
RCVR ANT. GAIN	-	-	-0.52	-
TRANSMISSION LOS	-	-	123.89	-
FIELD STRENGTH	-	-	34.23	-
SIGNAL POWER	-	-	-93.09	-
S/N IN DB	-	-	64.81	-
FRACTION OF DAYS	-	-	0.50	-
FRACTION OF S/N	-	-	0.96	-
RELIABILITY	-	-	0.48	-
SERVICE PROBABLE	-	-	0.47	-

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.6  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.008

UT = 07

# REFLECTION AREA DATA

1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.344	40.454	40.454
LONGITUDE	97.661	97.661	97.661	97.661
GEOMAGNETIC LAT	50.258	50.258	50.258	50.258
TIME IN HOURS	0.489	0.000	0.000	0.000
ABSORP. FACTOR	0.010	0.000	0.000	0.000
E-LAYER CRITICAL	0.508	0.000	0.000	0.000
F-LAYER BOTTOM	306.600	0.000	0.000	0.000
HEIGHT OF FMAX	374.373	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	5.706	0.000	0.000	0.000
ES MEAN	0.000	0.000	0.000	0.000

TIME AT RECEIVER 23.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.51  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 374.22 SEMI-THICKNESS 67.77  
 F-LAYER CRITICAL 5.71 HUF 9.56 FOT 7.55 HPF 10.99  
 EXCESS SYS LOSS 11.10 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56 9.56

# NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
NUMBER OF HOPS	1	2	3	0
TAKE-OFF ANGLE	0.00	0.00	29.83	52.57
VIRTUAL HEIGHT	0.00	0.00	427.81	459.37
TIME DELAY IN MS	-	-	5.27	4.74
SKY WAVE LOSS	-	-	116.02	-
ABSORPTION LOSS	-	-	0.06	-
GROUND REF. LOSS	-	-	0.00	-
XMTX ANT. GAIN	-	-	3.81	-
RCVR ANT. GAIN	-	-	-0.52	-
TRANSMISSION LOS	-	-	123.89	-
FIELD STRENGTH	-	-	34.23	-
SIGNAL POWER	-	-	-93.09	-
S/N IN DB	-	-	64.81	-
FRACTION OF DAYS	-	-	0.50	-
FRACTION OF S/N	-	-	0.96	-
RELIABILITY	-	-	0.48	-
SERVICE PROBABLE	-	-	0.47	-

# NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
NUMBER OF HOPS	1	2	3	0
TAKE-OFF ANGLE	0.00	0.00	22.51	42.25
VIRTUAL HEIGHT	0.00	0.00	309.81	314.13
TIME DELAY IN MS	-	-	4.87	6.09
SKY WAVE LOSS	-	-	104.25	106.19
ABSORPTION LOSS	-	-	0.34	0.41
GROUND REF. LOSS	-	-	0.00	5.27
XMTX ANT. GAIN	-	-	-4.93	-1.45
RCVR ANT. GAIN	-	-	1.22	-0.52
TRANSMISSION LOS	-	-	119.39	124.94
FIELD STRENGTH	-	-	25.90	22.09
SIGNAL POWER	-	-	-88.60	-94.15
S/N IN DB	-	-	48.32	42.77
FRACTION OF DAYS	-	-	0.99	0.99
FRACTION OF S/N	-	-	0.75	0.60
RELIABILITY	-	-	0.75	0.59
SERVICE PROBABLE	-	-	0.03	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS HILES KM.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
XNTR 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KM 3 MHZ NOISE=-14.8.608H TIME= 90 PERCENT REQ.S/N=40.008  
UT = 09

1 REFLECTION AREA DATA  
DISTANCE FROM TX 643.890 321.945 965.836 643.890 643.890  
LATITUDE 40.454 40.439 40.344 40.454 40.454  
LONGITUDE 97.661 93.856 101.460 97.661 97.661  
GEOMAGNETIC LAT 50.258 50.651 49.693 50.258 50.258  
TIME IN HOURS 2.489 0.000 0.000 0.000 0.000  
ABSORP. FACTOR 0.010 0.000 0.000 0.000 0.000  
E-LAYER CRITICAL 305.793 0.000 0.000 0.000 0.000  
F-LAYER BOTTOM 377.673 0.000 0.000 0.000 0.000  
HEIGHT OF FMAX 5.367 0.000 0.000 0.000 0.000  
GYRO-FREQUENCY 1.537 0.000 0.000 0.000 0.000  
F-LAYER CRITICAL 0.000 0.000 0.000 0.000 0.000  
ES MEDIAN 0.000 0.000 0.000 0.000 0.000

TIME AT RECEIVER 1.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.59  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 377.44 SEMI-THICKNESS 71.88  
F-LAYER CRITICAL 5.37 MUF 0.92 FOT 7.31 HPF 10.34  
EXCESS SYS LOSS 10.00 ESH 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-157.14 -175.41 -162.51 1.00 -0.57 -156.71  
E-MODES F-MODES EF-MODES

NUMBER OF HOPS 1 2 3 0 0  
TAKE-OFF ANGLE 0.00 29.96 52.75 64.51 -  
VIRTUAL HEIGHT 0.00 429.96 462.44 480.38 -  
TIME DELAY IN MS - 5.28 7.61 -  
SKY WAVE LOSS - 115.45 118.62 -  
ABSORPTION LOSS - 0.06 0.08 -  
GROUND REF. LOSS - 0.00 8.34 -  
XNTR ANT. GAIN - 4.78 -1.41 -  
RCVR ANT. GAIN - -0.45 -3.44 -  
TRANSMISSION LOSS - 121.18 141.89 -  
FIELD STRENGTH - 36.27 18.55 -  
SIGNAL POWER - -90.39 -111.10 -  
S/N IN OB - 68.32 45.61 -  
FRACTION OF DAYS - 0.50 0.00 -  
FRACTION OF S/N - 0.97 0.69 -  
RELIABILITY - 0.48 0.00 -  
SERVICE PROBABLE - 0.48 0.00 -

FREQUENCY = 8.917 MHZ  
NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-137.16 -204.00 -147.09 0.00 -0.57 -137.73  
E-MODES F-MODES EF-MODES

NUMBER OF HOPS 1 2 3 0 0  
TAKE-OFF ANGLE 0.00 22.60 42.35 54.50 -  
VIRTUAL HEIGHT 0.00 309.62 314.84 318.61 -  
TIME DELAY IN MS - 4.87 6.10 7.77 -  
SKY WAVE LOSS - 104.26 106.21 108.31 -  
ABSORPTION LOSS - 0.36 0.41 0.51 -  
GROUND REF. LOSS - 0.00 5.27 10.69 -  
XNTR ANT. GAIN - -4.90 -1.45 -  
RCVR ANT. GAIN - 1.22 -0.53 -2.88 -  
TRANSMISSION LOSS - 110.27 123.86 133.49 -  
FIELD STRENGTH - 27.02 23.18 15.90 -  
SIGNAL POWER - -87.48 -93.07 -102.70 -  
S/N IN OB - 50.25 44.66 35.03 -  
FRACTION OF DAYS - 0.99 0.99 0.99 -  
FRACTION OF S/N - 0.79 0.65 0.31 -  
RELIABILITY - 0.78 0.65 0.31 -  
SERVICE PROBABLE - 0.06 0.00 0.00 -

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS HILES KM.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
XNTR 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KM 3 MHZ NOISE=-14.8.608H TIME= 90 PERCENT REQ.S/N=40.008  
UT = 10

1 REFLECTION AREA DATA  
DISTANCE FROM TX 643.890 321.945 965.836 643.890 643.890  
LATITUDE 40.454 40.439 40.344 40.454 40.454  
LONGITUDE 97.661 93.856 101.460 97.661 97.661  
GEOMAGNETIC LAT 50.258 50.651 49.693 50.258 50.258  
TIME IN HOURS 3.489 0.000 0.000 0.000 0.000  
ABSORP. FACTOR 0.010 0.000 0.000 0.000 0.000  
E-LAYER CRITICAL 303.683 0.000 0.000 0.000 0.000  
F-LAYER BOTTOM 373.853 0.000 0.000 0.000 0.000  
HEIGHT OF FMAX 5.537 0.000 0.000 0.000 0.000  
GYRO-FREQUENCY 1.537 0.000 0.000 0.000 0.000  
F-LAYER CRITICAL 0.000 0.000 0.000 0.000 0.000  
ES MEDIAN 0.000 0.000 0.000 0.000 0.000

TIME AT RECEIVER 2.98 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 0.81  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 373.38 SEMI-THICKNESS 70.17  
F-LAYER CRITICAL 5.18 MUF 8.67 FOT 7.11 HPF 10.05  
EXCESS SYS LOSS 10.00 ESH 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-157.37 -175.14 -162.15 1.00 -0.57 -156.94  
E-MODES F-MODES EF-MODES

NUMBER OF HOPS 1 2 3 0 0  
TAKE-OFF ANGLE 0.00 29.68 52.40 64.21 -  
VIRTUAL HEIGHT 0.00 424.93 456.17 481.23 -  
TIME DELAY IN MS - 5.26 7.54 -  
SKY WAVE LOSS - 115.17 118.29 -  
ABSORPTION LOSS - 0.07 0.08 -  
GROUND REF. LOSS - 0.00 8.28 -  
XNTR ANT. GAIN - 5.28 -1.36 -  
RCVR ANT. GAIN - -0.41 -3.35 -  
TRANSMISSION LOSS - 120.37 141.57 -  
FIELD STRENGTH - 36.79 18.73 -  
SIGNAL POWER - -89.58 -110.58 -  
S/N IN OB - 67.36 46.36 -  
FRACTION OF DAYS - 0.50 0.00 -  
FRACTION OF S/N - 0.97 0.71 -  
RELIABILITY - 0.48 0.00 -  
SERVICE PROBABLE - 0.48 0.00 -

FREQUENCY = 2.666 MHZ  
NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
-140.07 -204.00 -147.09 0.00 -0.57 -140.64  
E-MODES F-MODES EF-MODES

NUMBER OF HOPS 1 2 3 0 0  
TAKE-OFF ANGLE 5.88 0.00 22.92 42.33 54.44  
VIRTUAL HEIGHT 100.28 0.00 307.55 313.01 316.91  
TIME DELAY IN MS 4.38 4.86 6.09 7.75  
SKY WAVE LOSS 103.33 104.27 106.20 108.29  
ABSORPTION LOSS 0.69 0.33 0.41 0.51  
GROUND REF. LOSS 0.00 5.27 10.69  
XNTR ANT. GAIN -10.00 -4.80 -1.45 -1.10  
RCVR ANT. GAIN -2.09 1.22 -0.53 -2.87  
TRANSMISSION LOSS 126.11 118.19 123.86 133.47  
FIELD STRENGTH 22.40 27.10 23.18 15.91  
SIGNAL POWER -95.32 -87.40 -93.06 -102.67  
S/N IN OB 45.32 53.25 47.58 37.97  
FRACTION OF DAYS 0.99 0.99 0.99  
FRACTION OF S/N 0.66 0.83 0.72 0.43  
RELIABILITY 0.66 0.83 0.72 0.43  
SERVICE PROBABLE 0.00 0.16 0.01 0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-149.608W TIME= 90 PERCENT REQ.S/N=40.008

UT = 12

# REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.439	40.439	40.344	40.439	40.439
LONGITUDE	97.661	97.661	97.661	97.661	97.661
GEOMAGNETIC LAT	50.258	50.258	50.258	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.000	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	1.200	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	292.942	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	361.502	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	5.244	0.000	0.000	0.000	0.000
ES MEAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 3.96 ABSORP. FACTOR 0.01 E-LAYER CRITICAL 1.20  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 360.45 SEMI-THICKNESS 68.56  
 F-LAYER CRITICAL 5.24 MUF 8.96 FOT 7.35 HPF 11.10  
 EXCESS SYS LOSS 10.00 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 10.05 9.54 9.03 8.52 8.01 7.50 6.99 6.48 5.97 5.46

# NOISE-ATMOSPHERIC

GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -159.68 -176.46 -162.57 1.30 -0.57 -158.46  
 E-MODES F-MODES  
 1 2 3 0 0

	1	2	3	0
NUMBER OF HOPS	0.00	28.80	51.16	63.45
TAKE-OFF ANGLE	0.00	409.54	434.75	463.73
VIRTUAL HEIGHT	0.00	5.21	7.31	11.10
TIME DELAY IN MS	0.00	115.37	118.32	119.10
SKY WAVE LOSS	0.00	0.06	0.08	0.08
ABSORPTION LOSS	0.00	0.00	0.00	0.00
GROUND REF. LOSS	0.00	5.28	-0.86	-1.23
XMTX ANT. GAIN	0.00	-0.41	-3.12	-2.98
RCVR ANT. GAIN	0.00	120.56	140.69	143.50
TRANSMISSION LOS	0.00	36.89	19.47	17.55
FIELD STRENGTH	0.00	-89.77	-109.90	-112.71
SIGNAL POWER	0.00	68.69	48.56	48.88
S/N IN OB	0.00	0.50	0.00	0.00
FRACTION OF DAYS	0.00	0.94	0.72	0.72
FRACTION OF S/N	0.00	0.47	3.00	0.00
RELIABILITY	0.00	0.44	0.00	0.00
SERVICE PROBABLE	0.00	0.00	0.00	0.00

# NOISE-ATMOSPHERIC

GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -144.50 -204.00 -147.09 1.80 -0.57 -143.27  
 E-MODES F-MODES  
 1 2 3 0 0

	1	2	3	0
NUMBER OF HOPS	5.33	16.13	24.83	53.70
TAKE-OFF ANGLE	93.86	102.83	296.68	304.74
VIRTUAL HEIGHT	4.37	4.54	4.95	6.03
TIME DELAY IN MS	103.31	103.65	104.39	106.11
SKY WAVE LOSS	0.71	0.86	0.31	0.41
ABSORPTION LOSS	0.00	4.10	0.00	5.26
GROUND REF. LOSS	0.00	-7.41	4.25	-1.49
XMTX ANT. GAIN	0.00	1.17	-0.45	-1.09
RCVR ANT. GAIN	126.57	125.01	117.78	123.72
TRANSMISSION LOS	22.49	20.49	27.56	23.24
FIELD STRENGTH	-95.78	-94.21	-66.99	-92.93
SIGNAL POWER	47.49	49.06	56.28	50.34
S/N IN OB	0.99	0.99	0.99	0.99
FRACTION OF DAYS	0.69	0.72	0.83	0.74
FRACTION OF S/N	0.68	0.71	0.82	0.74
RELIABILITY	0.00	0.00	0.00	0.00
SERVICE PROBABLE	0.00	0.00	0.00	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTV 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.0 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608W TIME= 90 PERCENT REQ.S/N=40.008

UT = 14

# REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.000	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	2.873	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	233.350	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	334.035	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	7.532	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 6.98 ABSORP. FACTOR 0.74 E-LAYER CRITICAL 2.87  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 330.83 SEMI-THICKNESS 100.68  
 F-LAYER CRITICAL 7.53 MUF 13.26 FOT 12.16 HPF 15.51  
 EXCESS SYS LOSS 11.70 ESM 0.00 ESL 0.00 K=8 K=9  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 14.71 14.02 13.33 12.64 11.95 11.26 10.56 9.87 9.18 8.49

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -179.20 -163.24 0.00 -0.57 -163.81  
 E-MODES F-MODES

	1	2	3
NUMBER OF HOPS	0.00	0.00	26.31
TAKE-OFF ANGLE	0.00	0.00	49.55
VIRTUAL HEIGHT	0.00	0.00	366.86
TIME DELAY IN MS	-	-	407.58
SKY WAVE LOSS	-	-	118.52
ABSORPTION LOSS	-	-	2.65
GROUND REF. LOSS	-	-	0.00
XMTV ANT. GAIN	-	-	0.86
RCVR ANT. GAIN	-	-	-0.79
TRANSMISSION LOS	-	-	132.80
FIELD STRENGTH	-	-	28.43
SIGNAL POWER	-	-	-102.01
S/N IN DB	-	-	61.81
FRACTION OF DAYS	-	-	0.50
FRACTION OF S/N	-	-	0.91
RELIABILITY	-	-	0.46
SERVICE PROBABLE	-	-	0.31

FREQUENCY = 2.666 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -204.00 -147.09 0.00 -0.57 -147.67  
 E-MODES F-MODES

	1	2	3
NUMBER OF HOPS	5.05	14.31	-90.00
TAKE-OFF ANGLE	90.61	91.54	242.62
VIRTUAL HEIGHT	4.37	4.49	-
TIME DELAY IN MS	103.31	103.56	-
SKY WAVE LOSS	52.82	68.84	-
ABSORPTION LOSS	0.00	3.87	-
GROUND REF. LOSS	-10.00	-8.35	-
XMTV ANT. GAIN	-2.82	0.83	-
RCVR ANT. GAIN	180.65	195.50	-
TRANSMISSION LOS	-31.32	-49.81	-
FIELD STRENGTH	-149.85	-164.70	-
SIGNAL POWER	-2.19	-17.04	-
S/N IN DB	0.99	0.99	-
FRACTION OF DAYS	0.00	0.00	-
FRACTION OF S/N	0.00	0.00	-
RELIABILITY	0.00	0.00	-
SERVICE PROBABLE	0.00	0.00	-

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTV 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.0 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608W TIME= 90 PERCENT REQ.S/N=40.008

UT = 13

# REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.000	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	2.326	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	252.754	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	334.124	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	6.626	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 5.98 ABSORP. FACTOR 0.50 E-LAYER CRITICAL 2.33  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 331.47 SEMI-THICKNESS 81.37  
 F-LAYER CRITICAL 6.63 MUF 11.78 FOT 9.84 HPF 13.78  
 EXCESS SYS LOSS 10.00 ESM 0.00 ESL 0.00 K=8 K=9  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 13.07 12.45 11.84 11.22 10.61 10.00 9.38 8.77 8.15 7.54

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -168.72 -178.07 -163.58 0.00 -0.57 -163.15  
 E-MODES F-MODES

	1	2	3
NUMBER OF HOPS	0.00	0.00	26.89
TAKE-OFF ANGLE	0.00	0.00	49.35
VIRTUAL HEIGHT	0.00	0.00	373.58
TIME DELAY IN MS	-	-	405.11
SKY WAVE LOSS	-	-	117.52
ABSORPTION LOSS	-	-	2.18
GROUND REF. LOSS	-	-	0.00
XMTV ANT. GAIN	-	-	1.34
RCVR ANT. GAIN	-	-	-0.67
TRANSMISSION LOS	-	-	129.03
FIELD STRENGTH	-	-	31.05
SIGNAL POWER	-	-	-98.24
S/N IN DB	-	-	64.91
FRACTION OF DAYS	-	-	0.50
FRACTION OF S/N	-	-	0.91
RELIABILITY	-	-	0.46
SERVICE PROBABLE	-	-	0.33

FREQUENCY = 2.666 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -156.31 -204.00 -147.09 0.00 -0.57 -147.67  
 E-MODES F-MODES

	1	2	3
NUMBER OF HOPS	5.08	14.46	65.61
TAKE-OFF ANGLE	90.95	92.43	262.07
VIRTUAL HEIGHT	4.37	4.50	10.83
TIME DELAY IN MS	103.31	103.56	111.20
SKY WAVE LOSS	35.84	46.47	38.38
ABSORPTION LOSS	0.00	3.89	21.48
GROUND REF. LOSS	-10.00	-8.27	-1.96
XMTV ANT. GAIN	-2.79	0.84	-6.11
RCVR ANT. GAIN	161.94	171.35	188.79
TRANSMISSION LOS	-12.64	-25.69	-36.18
FIELD STRENGTH	-131.15	-140.56	-158.00
SIGNAL POWER	16.52	7.11	-10.34
S/N IN DB	0.99	0.99	0.99
FRACTION OF DAYS	0.00	0.00	0.00
FRACTION OF S/N	0.00	0.00	0.00
RELIABILITY	0.00	0.00	0.00
SERVICE PROBABLE	0.00	0.00	0.00

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KM 3 MHZ NOISE=-148.608B TIME= 90 PERCENT REQ.S/N=40.008

UT = 16

# REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	1.115	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	3.583	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	214.586	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	361.306	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	8.695	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 8.98 ABSORP. FACTOR 1.12 E-LAYER CRITICAL 3.58  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 357.47 SEMI-THICKNESS 146.72  
 F-LAYER CRITICAL 8.69 MUF 15.17 FOT 15.17 HPF 16.84  
 EXCESS SYS LOSS 11.70 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 15.17 15.17 15.17 15.17 15.17 15.17 15.17 15.17 15.17 15.17

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -176.67 -180.49 -162.85 0.00 -0.57 -163.43  
 F-MODES 1 2 3 0

	1	2	3	0
NUMBER OF HOPS	7.96	0.00	27.09	52.69
TAKE-OFF ANGLE	124.76	0.00	377.81	458.16
VIRTUAL HEIGHT	4.41	5.10	549.84	
TIME DELAY IN MS	118.50	119.76		
SKY WAVE LOSS	6.72	3.10		
ABSORPTION LOSS	0.00	0.00		
GROUND REF. LOSS	3.62	3.19		
XMTX ANT. GAIN	-4.73	-0.91		
RCVR ANT. GAIN	138.04	132.28		
TRANSMISSION LOS	28.30	30.24		
FIELD STRENGTH	-107.24	-101.49		
SIGNAL POWER	56.18	61.94		
S/N IN OB	0.99	0.36		
FRACTION OF DAYS	0.85	0.91		
FRACTION OF S/N	0.85	0.91		
RELIABILITY	0.85	0.91		
SERVICE PROBABLE	0.19	0.23		

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -175.58 -180.40 -147.09 0.00 -0.57 -147.67  
 F-MODES 1 2 3 0

	1	2	3	0
NUMBER OF HOPS	5.03	14.22	-90.00	0.00
TAKE-OFF ANGLE	90.39	90.97	224.15	0.00
VIRTUAL HEIGHT	4.37	4.49		
TIME DELAY IN MS	103.31	103.55		
SKY WAVE LOSS	79.82	104.39		
ABSORPTION LOSS	0.00	3.86		
GROUND REF. LOSS	-10.00	-8.40		
XMTX ANT. GAIN	-2.84	0.81		
RCVR ANT. GAIN	207.66	234.09		
TRANSMISSION LOS	-58.32	-85.39		
FIELD STRENGTH	-29.87	-200.30		
SIGNAL POWER	-29.20	-52.63		
S/N IN OB	0.99	0.99		
FRACTION OF DAYS	0.00	0.00		
FRACTION OF S/N	0.00	0.00		
RELIABILITY	0.00	0.00		
SERVICE PROBABLE	0.00	0.00		

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KM 3 MHZ NOISE=-148.608B TIME= 90 PERCENT REQ.S/N=40.008

UT = 15

# REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.947	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	3.301	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	229.859	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	345.020	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	8.216	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 7.98 ABSORP. FACTOR 0.95 E-LAYER CRITICAL 3.30  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 341.41 SEMI-THICKNESS 125.16  
 F-LAYER CRITICAL 8.22 MUF 14.06 FOT 13.97 HPF 16.45  
 EXCESS SYS LOSS 11.70 ESM 0.00 ESL 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 15.60 14.87 14.14 13.40 12.67 11.94 11.20 10.47 9.74 9.00

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -175.32 -179.76 -163.07 0.00 -0.57 -163.65  
 F-MODES 1 2 3 0

	1	2	3	0
NUMBER OF HOPS	0.00	0.00	26.50	50.88
TAKE-OFF ANGLE	0.00	0.00	369.05	427.99
VIRTUAL HEIGHT	5.07	5.07	499.96	
TIME DELAY IN MS	119.05	119.05		
SKY WAVE LOSS	3.06	0.00		
ABSORPTION LOSS	1.93	0.00		
GROUND REF. LOSS	-0.84	-0.84		
XMTX ANT. GAIN	132.72	132.72		
RCVR ANT. GAIN	29.08	29.08		
TRANSMISSION LOS	-101.92	-101.92		
FIELD STRENGTH	61.72	61.72		
SIGNAL POWER	3.50	3.50		
S/N IN OB	0.91	0.91		
FRACTION OF DAYS	0.46	0.46		
FRACTION OF S/N	0.31	0.31		
RELIABILITY				
SERVICE PROBABLE				

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -170.85 -180.40 -147.09 0.00 -0.57 -147.67  
 F-MODES 1 2 3 0

	1	2	3	0
NUMBER OF HOPS	5.04	14.25	-90.00	0.00
TAKE-OFF ANGLE	90.46	91.15	229.12	0.00
VIRTUAL HEIGHT	4.37	4.49		
TIME DELAY IN MS	103.31	103.56		
SKY WAVE LOSS	67.77	88.54		
ABSORPTION LOSS	0.00	3.86		
GROUND REF. LOSS	-10.00	-8.39		
XMTX ANT. GAIN	-2.83	0.82		
RCVR ANT. GAIN	195.61	215.22		
TRANSMISSION LOS	-46.27	-69.53		
FIELD STRENGTH	-164.82	-184.43		
SIGNAL POWER	-17.15	-36.76		
S/N IN OB	0.99	0.99		
FRACTION OF DAYS	0.00	0.00		
FRACTION OF S/N	0.00	0.00		
RELIABILITY	0.00	0.00		
SERVICE PROBABLE	0.00	0.00		

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES KM.  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.00B

UT = 18

REFLECTION AREA DATA  
 1 2 3 4 5  
 DISTANCE FROM TX 643.890 321.945 965.836 643.890 643.890  
 LATITUDE 40.454 40.439 40.344 40.454 40.454  
 LONGITUDE 97.661 93.856 101.460 97.661 97.661  
 GEOMAGNETIC LAT 50.258 50.651 49.693 50.258 50.258  
 TIME IN HOURS 11.489 0.000 0.000 0.000 0.000  
 ABSORP. FACTOR 1.294 0.000 0.000 0.000 0.000  
 E-LAYER CRITICAL 3.801 0.000 0.000 0.000 0.000  
 F-LAYER BOTTOM 217.857 0.000 0.000 0.000 0.000  
 HEIGHT OF FMAX 381.405 0.000 0.000 0.000 0.000  
 GYRO-FREQUENCY 1.537 0.000 0.000 0.000 0.000  
 F-LAYER CRITICAL 9.623 0.000 0.000 0.000 0.000  
 ES MEDIAN 0.000 0.000 0.000 0.000 0.000

TIME AT RECEIVER 10.98 ABSORP. FACTOR 1.29 E-LAYER CRITICAL 3.80  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 377.93 SEMI-THICKNESS 163.55  
 F-LAYER CRITICAL 9.62 MUF 16.09 FOT 16.09 HPF 17.81  
 EXCESS SYS LOSS 10.80 ESM 0.00 ESL 0.00 K=7 K=8 K=9  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 16.09 16.09 16.09 16.09 16.09 16.09 16.09 16.09 16.09 16.09

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -175.88 -161.05 -162.69 0.00 -0.57 -163.26  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 3 0 0  
 TAKE-OFF ANGLE 7.96 0.00 28.19 54.85 69.01  
 VIRTUAL HEIGHT 124.76 0.00 396.01 498.71 614.72  
 TIME DELAY IN MS 4.41 - 5.17 -  
 SKY WAVE LOSS 119.02 - 120.38 -  
 ABSORPTION LOSS 7.03 - 3.14 -  
 GROUND REF. LOSS 0.00 - 0.00 -  
 XMTX ANT. GAIN 2.72 - 2.83 -  
 RCVR ANT. GAIN -4.81 - -0.97 -  
 TRANSMISSION LOS 138.94 - 132.46 -  
 FIELD STRENGTH 28.00 - 30.63 -  
 SIGNAL POWER -108.15 - -101.67 -  
 S/N IN DB 55.11 - 61.59 -  
 FRACTION OF DAYS 0.99 - 0.37 -  
 FRACTION OF S/N 0.85 - 0.91 -  
 RELIABILITY 0.84 - 0.33 -  
 SERVICE PROBABLE 0.14 - 0.22 -

FREQUENCY = 16.093 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -178.39 -204.00 -147.09 0.00 -0.57 -147.67  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 \* 0 0  
 TAKE-OFF ANGLE 5.03 14.21 -90.00 0.00 0.00  
 VIRTUAL HEIGHT 90.36 90.89 224.86 0.00 0.00  
 TIME DELAY IN MS 4.37 4.49 -  
 SKY WAVE LOSS 103.31 103.55 -  
 ABSORPTION LOSS 88.27 115.50 -  
 GROUND REF. LOSS 0.00 3.85 -  
 XMTX ANT. GAIN -10.00 -8.41 -  
 RCVR ANT. GAIN -2.84 0.81 -  
 TRANSMISSION LOS 215.21 241.30 -  
 FIELD STRENGTH -65.87 -95.61 -  
 SIGNAL POWER -184.62 -210.51 -  
 S/N IN DB -36.76 -62.85 -  
 FRACTION OF DAYS 0.99 0.99 -  
 FRACTION OF S/N 0.00 0.00 -  
 RELIABILITY 0.00 0.00 -  
 SERVICE PROBABLE 0.00 0.00 -

FREQUENCY = 2.666 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -178.60 -204.00 -147.09 0.00 -0.57 -147.67  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 \* 0 0  
 TAKE-OFF ANGLE 5.03 14.21 -90.00 0.00 0.00  
 VIRTUAL HEIGHT 90.36 90.89 224.86 0.00 0.00  
 TIME DELAY IN MS 4.37 4.49 -  
 SKY WAVE LOSS 103.31 103.55 -  
 ABSORPTION LOSS 88.27 115.50 -  
 GROUND REF. LOSS 0.00 3.85 -  
 XMTX ANT. GAIN -10.00 -8.41 -  
 RCVR ANT. GAIN -2.84 0.81 -  
 TRANSMISSION LOS 215.21 241.30 -  
 FIELD STRENGTH -65.87 -95.61 -  
 SIGNAL POWER -184.62 -210.51 -  
 S/N IN DB -36.76 -62.85 -  
 FRACTION OF DAYS 0.99 0.99 -  
 FRACTION OF S/N 0.00 0.00 -  
 RELIABILITY 0.00 0.00 -  
 SERVICE PROBABLE 0.00 0.00 -

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES KM.  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.60BW TIME= 90 PERCENT REQ.S/N=40.00B

UT = 17

REFLECTION AREA DATA  
 1 2 3 4 5  
 DISTANCE FROM TX 643.890 321.945 965.836 643.890 643.890  
 LATITUDE 40.454 40.439 40.344 40.454 40.454  
 LONGITUDE 97.661 93.856 101.460 97.661 97.661  
 GEOMAGNETIC LAT 50.258 50.651 49.693 50.258 50.258  
 TIME IN HOURS 10.489 0.000 0.000 0.000 0.000  
 ABSORP. FACTOR 1.233 0.000 0.000 0.000 0.000  
 E-LAYER CRITICAL 3.737 0.000 0.000 0.000 0.000  
 F-LAYER BOTTOM 215.491 0.000 0.000 0.000 0.000  
 HEIGHT OF FMAX 374.942 0.000 0.000 0.000 0.000  
 GYRO-FREQUENCY 1.537 0.000 0.000 0.000 0.000  
 F-LAYER CRITICAL 9.143 0.000 0.000 0.000 0.000  
 ES MEDIAN 0.000 0.000 0.000 0.000 0.000

TIME AT RECEIVER 9.98 ABSORP. FACTOR 1.23 E-LAYER CRITICAL 3.74  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 371.18 SEMI-THICKNESS 159.45  
 F-LAYER CRITICAL 9.14 MUF 15.82 FOT 15.82 HPF 17.12  
 EXCESS SYS LOSS 10.80 ESM 0.00 ESL 0.00 K=7 K=8 K=9  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 15.82 15.82 15.82 15.82 15.82 15.82 15.82 15.82 15.82 15.82

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -176.10 -160.89 -162.73 0.00 -0.57 -163.31  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 3 0 0  
 TAKE-OFF ANGLE 7.96 0.00 27.77 54.17 68.58  
 VIRTUAL HEIGHT 124.76 0.00 388.84 485.24 599.67  
 TIME DELAY IN MS 4.41 - 5.14 -  
 SKY WAVE LOSS 118.87 - 120.19 -  
 ABSORPTION LOSS 6.90 - 3.12 -  
 GROUND REF. LOSS 0.00 - 0.00 -  
 XMTX ANT. GAIN 3.00 - 3.17 -  
 RCVR ANT. GAIN -4.79 - -0.95 -  
 TRANSMISSION LOS 138.36 - 131.90 -  
 FIELD STRENGTH 28.40 - 31.03 -  
 SIGNAL POWER -107.57 - -101.10 -  
 S/N IN DB 55.74 - 62.20 -  
 FRACTION OF DAYS 0.99 - 0.36 -  
 FRACTION OF S/N 0.85 - 0.92 -  
 RELIABILITY 0.85 - 0.28 -  
 SERVICE PROBABLE 0.17 - 0.20 -

FREQUENCY = 15.821 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -178.60 -204.00 -147.09 0.00 -0.57 -147.67  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 \* 0 0  
 TAKE-OFF ANGLE 5.03 14.21 -90.00 0.00 0.00  
 VIRTUAL HEIGHT 90.36 90.89 224.86 0.00 0.00  
 TIME DELAY IN MS 4.37 4.49 -  
 SKY WAVE LOSS 103.31 103.55 -  
 ABSORPTION LOSS 88.27 115.50 -  
 GROUND REF. LOSS 0.00 3.85 -  
 XMTX ANT. GAIN -10.00 -8.41 -  
 RCVR ANT. GAIN -2.84 0.81 -  
 TRANSMISSION LOS 215.21 241.30 -  
 FIELD STRENGTH -65.87 -95.61 -  
 SIGNAL POWER -184.62 -210.51 -  
 S/N IN DB -36.76 -62.85 -  
 FRACTION OF DAYS 0.99 0.99 -  
 FRACTION OF S/N 0.00 0.00 -  
 RELIABILITY 0.00 0.00 -  
 SERVICE PROBABLE 0.00 0.00 -

FREQUENCY = 2.666 MHZ  
 NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING  
 -178.60 -204.00 -147.09 0.00 -0.57 -147.67  
 F-MODES E-MODES  
 NUMBER OF HOPS 1 2 \* 0 0  
 TAKE-OFF ANGLE 5.03 14.21 -90.00 0.00 0.00  
 VIRTUAL HEIGHT 90.36 90.89 224.86 0.00 0.00  
 TIME DELAY IN MS 4.37 4.49 -  
 SKY WAVE LOSS 103.31 103.55 -  
 ABSORPTION LOSS 88.27 115.50 -  
 GROUND REF. LOSS 0.00 3.85 -  
 XMTX ANT. GAIN -10.00 -8.41 -  
 RCVR ANT. GAIN -2.84 0.81 -  
 TRANSMISSION LOS 215.21 241.30 -  
 FIELD STRENGTH -65.87 -95.61 -  
 SIGNAL POWER -184.62 -210.51 -  
 S/N IN DB -36.76 -62.85 -  
 FRACTION OF DAYS 0.99 0.99 -  
 FRACTION OF S/N 0.00 0.00 -  
 RELIABILITY 0.00 0.00 -  
 SERVICE PROBABLE 0.00 0.00 -

APRIL 15, 1969 10 CM FLUX 154 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES KM.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
MINIMUM ANGLE 0.0 DEGREES  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
PWR= 1.20KM 3 MHZ NOISE=-148.60DB TIME= 90 PERCENT REQ.S/N=40.008

UT = 20

REFLECTION AREA DATA				
1	2	3	4	5
OISTANCE FROM TX	643.890	321.945	965.836	643.890
LATITUDE	40.454	40.439	40.344	40.454
LONGITUDE	97.661	93.856	101.460	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258
TIME IN HOURS	13.449	0.000	0.000	0.000
ABSORP. FACTOR	1.235	0.000	0.000	0.000
E-LAYER CRITICAL	3.705	0.000	0.000	0.000
F-LAYER BOTTOM	225.567	0.000	0.000	0.000
HEIGHT OF FMAX	376.593	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000
F-LAYER CRITICAL	10.184	0.000	0.000	0.000
ES MECHAN	0.000	0.000	0.000	0.000
TIME AT RECEIVER	12.98	ABSORP. FACTOR	1.24	E-LAYER CRITICAL
GYRO-FREQUENCY	1.54	HEIGHT OF FMAX	375.95	SEMI-THICKNESS
F-LAYER CRITICAL	10.16	MUF	16.30	FOT
EXCESS SYS LOSS	10.20	ESL	0.00	ESU
K=0	K=1	K=2	K=3	K=4
16.30	16.30	16.30	16.30	16.30
K=5	K=6	K=7	K=8	K=9
16.30	16.30	16.30	16.30	16.30
155.34	18.90	18.90	18.90	18.90
0.30	0.30	0.30	0.30	0.30

UT = 19

REFLECTION AREA DATA				
1	2	3	4	5
DISTANCE FROM TX				
643.890	321.945	965.836	643.890	643.890
LATITUDE				
40.454	40.439	40.344	40.454	40.454
LONGITUDE				
97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT				
50.258	50.651	49.693	50.258	50.258
TIME IN HOURS				
12.489	0.000	0.000	0.000	0.000
ABSORP. FACTOR				
1.295	0.000	0.000	0.000	0.000
E-LAYER CRITICAL				
3.005	0.000	0.000	0.000	0.000
F-LAYER BOTTOM				
220.002	0.000	0.000	0.000	0.000
HEIGHT OF FMAX				
381.805	0.000	0.000	0.000	0.000
GYRO-FREQUENCY				
1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL				
10.007	0.000	0.000	0.000	0.000
ES MECHAN				
0.000	0.000	0.000	0.000	0.000
TIME AT RECEIVER				
11.98	ABSORP. FACTOR	1.29	E-LAYER CRITICAL	3.80
GYRO-FREQUENCY				
1.54	HEIGHT OF FMAX	378.63	SEMI-THICKNESS	161.80
F-LAYER CRITICAL				
10.01	MUF	16.11	FOT	16.11
EXCESS SYS LOSS				
10.80	ESL	0.00	ESL	0.00
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9				
16.11	16.11	16.11	16.11	16.11

FREQUENCY = 16.296 MHZ					
NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-173.28	-181.17	-162.65	0.00	-0.57	-163.22
E-MODES					
1	2	1	2	3	0
NUMBER OF HOPS	0.00	28.36	54.54	68.58	-
TAKE-OFF ANGLE	0.00	0.00	399.63	493.10	600.30
VIRTUAL HEIGHT	-	-	5.18	-	-
TIME DELAY IN MS	-	-	-	-	-
SKY WAVE LOSS	-	120.51	-	-	-
ABSORPTION LOSS	-	-	2.92	-	-
GROUND REF. LOSS	-	-	0.00	-	-
XMTX ANT. GAIN	-	-	2.47	-	-
RCVR ANT. GAIN	-	-	-0.98	-	-
TRANSMISSION LOS	-	132.14	-	-	-
FIELD STRENGTH	-	31.08	-	-	-
SIGNAL POWER	-	-101.35	-	-	-
S/N IN DB	-	61.88	-	-	-
FRACTION OF DAYS	-	0.50	-	-	-
FRACTION OF S/N	-	0.92	-	-	-
RELIABILITY	-	0.46	-	-	-
SERVICE PROBABLE	-	0.33	-	-	-

FREQUENCY = 16.106 MHZ					
NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-174.65	-181.06	-162.60	0.00	-0.57	-163.26
E-MODES					
1	2	3	2	3	0
NUMBER OF HOPS					
7.96	0.00	28.33	54.88	68.96	-
TAKE-OFF ANGLE					
124.76	0.00	398.69	499.56	613.17	-
VIRTUAL HEIGHT					
4.41	-	5.16	-	-	-
TIME DELAY IN MS					
119.02	-	120.41	-	-	-
SKY WAVE LOSS					
7.02	-	3.12	-	-	-
ABSORPTION LOSS					
0.00	-	0.00	-	-	-
GROUND REF. LOSS					
2.71	-	2.96	-	-	-
XTR ANT. GAIN					
-4.81	-	-0.97	-	-	-
RCVR ANT. GAIN					
138.95	-	132.54	-	-	-
TRANSMISSION LOS					
27.99	-	30.57	-	-	-
FIELD STRENGTH					
-104.16	-	-104.75	-	-	-
SIGNAL POWER					
S/N IN OB	-	164.51	-	-	-
55.10	-	55.10	-	-	-
FRACTION OF DAYS					
0.99	-	0.48	-	-	-
FRACTION OF S/N					
0.84	-	0.91	-	-	-
RELIABILITY					
0.43	-	0.43	-	-	-
SERVICE PROBABLE					
0.14	-	0.29	-	-	-

APRIL 15, 1969 10 CH FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOLDUER, COLD. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 DFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608M TIME= 90 PERCENT REQ.S/N=40.0DB

UT = 22

REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.951	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	3.302	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	232.880	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	361.414	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	10.069	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 14.98 ABSORP. FACTOR 0.95 E-LAYER CRITICAL 3.30  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 359.14 SEMI-THICKNESS 128.53  
 F-LAYER CRITICAL 10.17 MUF 16.71 FOT 13.98 HPF 18.71  
 EXCESS SYS LOSS 10.20 ESM 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45

FREQUENCY = 16.706 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-171.50	-181.41	-162.56	0.00	-0.57	-163.15
	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	27.85	52.58	66.25
VIRTUAL HEIGHT	0.00	0.00	392.40	457.72	530.42
TIME DELAY IN MS			5.15		
SKY WAVE LOSS	-	-	120.68	-	-
ABSORPTION LOSS	-	-	2.18	-	-
GROUND REF. LOSS	-	-	0.00	-	-
XMTX ANT. GAIN	-	-	2.01	-	-
RCVR ANT. GAIN	-	-	-0.99	-	-
TRANSMISSION LOSS	-	-	132.04	-	-
FIELD STRENGTH	-	-	31.40	-	-
SIGNAL POWER	-	-	-101.25	-	-
S/N IN DB	-	-	61.90	-	-
FRACTION OF DAYS	-	-	0.50	-	-
FRACTION OF S/N	-	-	0.92	-	-
RELIABILITY	-	-	0.46	-	-
SERVICE PROBABLE	-	-	0.33	-	-

FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-167.17	-204.00	-147.09	0.00	-0.57	-147.67
	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	*	*	0
TAKE-OFF ANGLE	5.04	14.22	-90.00	0.00	-
VIRTUAL HEIGHT	90.46	91.15	239.33	0.00	-
TIME DELAY IN MS	4.37	4.49	-	-	-
SKY WAVE LOSS	103.31	103.56	-	-	-
ABSORPTION LOSS	68.06	88.92	-	-	-
GROUND REF. LOSS	-	0.00	3.86	-	-
XMTX ANT. GAIN	-10.00	-8.39	-	-	-
RCVR ANT. GAIN	-2.83	0.82	-	-	-
TRANSMISSION LOSS	194.40	214.10	-	-	-
FIELD STRENGTH	-45.06	-68.41	-	-	-
SIGNAL POWER	-163.61	-183.31	-	-	-
S/N IN DB	-15.94	-35.64	-	-	-
FRACTION OF DAYS	0.99	0.99	-	-	-
FRACTION OF S/N	0.00	0.00	-	-	-
RELIABILITY	0.00	0.00	-	-	-
SERVICE PROBABLE	0.00	0.00	-	-	-

APRIL 15, 1969 10 CH FLUX 154 (SSN 106)  
 HAVANA, ILL. TO BOLDUER, COLD. AZIMUTHS MILES  
 40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
 MINIMUM ANGLE 0.0 DEGREES  
 XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
 RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 DFF AZ 0.0  
 POWER= 1.20KW 3 MHZ NOISE=-148.608M TIME= 90 PERCENT REQ.S/N=40.0DB

UT = 21

REFLECTION AREA DATA

	1	2	3	4	5
DISTANCE FROM TX	643.890	321.945	965.836	643.890	643.890
LATITUDE	40.454	40.439	40.344	40.454	40.454
LONGITUDE	97.661	93.856	101.460	97.661	97.661
GEOMAGNETIC LAT	50.258	50.651	49.693	50.258	50.258
TIME IN HOURS	0.000	0.000	0.000	0.000	0.000
ABSORP. FACTOR	0.951	0.000	0.000	0.000	0.000
E-LAYER CRITICAL	3.591	0.000	0.000	0.000	0.000
F-LAYER BOTTOM	228.501	0.000	0.000	0.000	0.000
HEIGHT OF FMAX	372.713	0.000	0.000	0.000	0.000
GYRO-FREQUENCY	1.537	0.000	0.000	0.000	0.000
F-LAYER CRITICAL	10.138	0.000	0.000	0.000	0.000
ES MEDIAN	0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 13.98 ABSORP. FACTOR 1.12 E-LAYER CRITICAL 3.59  
 GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 370.01 SEMI-THICKNESS 144.21  
 F-LAYER CRITICAL 10.14 MUF 16.65 FOT 15.20 HPF 18.42  
 EXCESS SYS LOSS 10.20 ESM 0.00 ESU 0.00  
 K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45 16.45

FREQUENCY = 16.446 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-171.53	-181.26	-162.62	0.00	-0.57	-163.20
	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	1	3	0
TAKE-OFF ANGLE	0.00	0.00	28.27	53.83	67.85
VIRTUAL HEIGHT	0.00	0.00	398.59	473.88	576.81
TIME DELAY IN MS	-	-	5.17	-	-
SKY WAVE LOSS	-	-	120.58	-	-
ABSORPTION LOSS	-	-	2.60	-	-
GROUND REF. LOSS	-	-	0.00	-	-
XMTX ANT. GAIN	-	-	2.26	-	-
RCVR ANT. GAIN	-	-	-0.98	-	-
TRANSMISSION LOSS	-	-	132.11	-	-
FIELD STRENGTH	-	-	31.18	-	-
SIGNAL POWER	-	-	-101.32	-	-
S/N IN DB	-	-	61.87	-	-
FRACTION OF DAYS	-	-	0.50	-	-
FRACTION OF S/N	-	-	0.92	-	-
RELIABILITY	-	-	0.46	-	-
SERVICE PROBABLE	-	-	0.33	-	-

FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC	GALACTIC	MAN-MADE	ADJUSTED	EFFICIENCY	CONTROLLING
-172.10	-204.00	-147.09	0.00	-0.57	-147.67
	E-MODES	F-MODES			EF-MODES
NUMBER OF HOPS	1	2	*	*	0
TAKE-OFF ANGLE	5.03	14.22	-90.00	0.00	-
VIRTUAL HEIGHT	90.39	90.97	235.44	0.00	-
TIME DELAY IN MS	4.37	4.49	-	-	-
SKY WAVE LOSS	103.31	103.55	-	-	-
ABSORPTION LOSS	80.04	104.68	-	-	-
GROUND REF. LOSS	-	0.00	3.86	-	-
XMTX ANT. GAIN	-10.00	-8.40	-	-	-
RCVR ANT. GAIN	-2.84	0.81	-	-	-
TRANSMISSION LOSS	206.30	229.80	-	-	-
FIELD STRENGTH	-57.04	-88.18	-	-	-
SIGNAL POWER	-175.59	-199.09	-	-	-
S/N IN DB	-27.92	-51.42	-	-	-
FRACTION OF DAYS	0.99	0.99	-	-	-
FRACTION OF S/N	0.00	0.00	-	-	-
RELIABILITY	0.00	0.00	-	-	-
SERVICE PROBABLE	0.00	0.00	-	-	-

APRIL 15, 1969 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES KM.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
MINIMUM ANGLE 0.0 DEGREES  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KW 3 MHZ NOISE=-14.608M TIME= 90 PERCENT REQ.S/N=40.008

UT = 24

REFLECTION AREA DATA

1	2	3	4	5
643.890	321.945	965.836	643.890	643.890
40.454	40.439	40.344	40.454	40.454
97.661	93.856	101.460	97.661	97.661
50.258	50.651	49.693	50.258	50.258
17.489	0.000	0.000	0.000	0.000
0.507	0.000	0.000	0.000	0.000
2.308	0.000	0.000	0.000	0.000
243.997	0.000	0.000	0.000	0.000
331.974	0.000	0.000	0.000	0.000
1.537	0.000	0.000	0.000	0.000
9.721	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 16.98 ABSORP. FACTOR 0.51 E-LAYER CRITICAL 2.31  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 330.84 SEMI-THICKNESS 87.98  
F-LAYER CRITICAL 9.72 MUF 17.28 FOT 13.82 HPF 19.35  
EXCESS SYS LOSS 11.70 ESM 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
19.29 18.20 17.11 16.01 14.92 13.82 12.73 11.64 10.54 9.45

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
-172.13	-181.73	-162.48	0.00	-0.57
E-MODES	F-MODES	F-MODES	F-MODES	EF-MODES
1	2	3	4	5
0.00	0.00	26.41	49.17	62.55
0.00	0.00	370.97	403.72	444.87
0.00	0.00	5.07	5.07	5.07
0.00	0.00	120.83	120.83	120.83
0.00	0.00	1.14	1.14	1.14
0.00	0.00	0.00	0.00	0.00
0.00	0.00	1.69	1.69	1.69
0.00	0.00	-1.01	-1.01	-1.01
0.00	0.00	132.99	132.99	132.99
0.00	0.00	30.76	30.76	30.76
0.00	0.00	-102.20	-102.20	-102.20
0.00	0.00	60.85	60.85	60.85
0.00	0.00	0.50	0.50	0.50
0.00	0.00	0.86	0.86	0.86
0.00	0.00	0.43	0.43	0.43
0.00	0.00	0.00	0.00	0.00

APRIL 15, 1969 (SSN 106)  
HAVANA, ILL. TO BOULDER, COLO. AZIMUTHS MILES KM.  
40.30N - 90.06W 40.11N - 105.24W 273.98 84.15 800.2 1287.8  
MINIMUM ANGLE 0.0 DEGREES  
XMTX 2.0 TO 30.0 TERM. SLOPING V H 24.38 L 76.20 A 35.0 OFF AZ 0.0  
RCVR 2.0 TO 30.0 VERTICAL H -0.00 L -0.25 A -0.0 OFF AZ 0.0  
POWER= 1.20KW 3 MHZ NOISE=-14.608M TIME= 90 PERCENT REQ.S/N=40.008

UT = 23

REFLECTION AREA DATA

1	2	3	4	5
643.890	321.945	965.836	643.890	643.890
40.454	40.439	40.344	40.454	40.454
97.661	93.856	101.460	97.661	97.661
50.258	50.651	49.693	50.258	50.258
16.489	0.000	0.000	0.000	0.000
0.743	0.000	0.000	0.000	0.000
2.863	0.000	0.000	0.000	0.000
237.340	0.000	0.000	0.000	0.000
345.969	0.000	0.000	0.000	0.000
1.537	0.000	0.000	0.000	0.000
9.980	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000

TIME AT RECEIVER 15.98 ABSORP. FACTOR 0.74 E-LAYER CRITICAL 2.86  
GYRO-FREQUENCY 1.54 HEIGHT OF FMAX 344.27 SEMI-THICKNESS 108.63  
F-LAYER CRITICAL 9.98 MUF 17.12 FOT 13.70 HPF 19.18  
EXCESS SYS LOSS 11.70 ESM 0.00 ESL 0.00 ESU 0.00  
K=0 K=1 K=2 K=3 K=4 K=5 K=6 K=7 K=8 K=9  
19.12 18.04 16.95 15.87 14.78 13.70 12.62 11.53 10.45 9.36

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
-171.95	-181.64	-162.51	0.00	-0.57
E-MODES	F-MODES	F-MODES	F-MODES	EF-MODES
1	2	3	4	5
0.00	0.00	27.13	50.86	64.45
0.00	0.00	381.56	429.36	485.71
0.00	0.00	5.11	5.11	5.11
0.00	0.00	120.82	120.82	120.82
0.00	0.00	1.67	1.67	1.67
0.00	0.00	0.00	0.00	0.00
0.00	0.00	1.59	1.59	1.59
0.00	0.00	-1.00	-1.00	-1.00
0.00	0.00	133.60	133.60	133.60
0.00	0.00	30.07	30.07	30.07
0.00	0.00	-102.80	-102.80	-102.80
0.00	0.00	60.28	60.28	60.28
0.00	0.00	0.50	0.50	0.50
0.00	0.00	0.86	0.86	0.86
0.00	0.00	0.43	0.43	0.43
0.00	0.00	0.00	0.00	0.00

FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
-162.20	-172.00	-147.09	0.00	-0.57
E-MODES	F-MODES	F-MODES	F-MODES	EF-MODES
1	2	3	4	5
5.05	14.32	-90.00	0.00	0.00
90.61	91.55	243.16	0.00	0.00
4.37	4.50	10.40	12.00	13.64
103.31	103.56	110.85	112.09	113.20
53.16	69.29	46.94	39.09	45.69
0.00	3.87	26.86	32.24	32.24
0.00	-8.35	-1.55	-1.86	-2.16
0.00	0.83	-5.75	-7.07	-8.24
180.99	195.94	205.27	219.93	219.93
-31.66	-50.25	-51.69	-65.16	-65.16
-150.20	-167.15	-159.62	-174.48	-189.14
-2.53	-17.46	-26.81	-41.48	-41.48
0.99	0.99	0.99	0.99	0.99
0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00

FREQUENCY = 2.666 MHZ

NOISE-ATMOSPHERIC GALACTIC MAN-MADE ADJUSTED EFFICIENCY CONTROLLING

1	2	3	4	5
-157.34	-167.09	0.00	-0.57	-147.67
E-MODES	F-MODES	F-MODES	F-MODES	EF-MODES
1	2	3	4	5
5.08	14.46	64.59	68.16	70.91
90.96	92.47	248.64	248.83	249.00
4.37	4.50	10.40	12.00	13.64
103.31	103.57	110.85	112.09	113.20
36.22	46.94	39.09	45.69	52.39
0.00	3.89	21.47	26.86	32.24
0.00	-8.27	-1.55	-1.86	-2.16
0.00	0.84	-5.75	-7.07	-8.24
164.01	173.52	205.27	219.93	219.93
14.72	-27.86	-38.15	-51.69	-65.16
-133.22	-142.73	-159.62	-174.48	-189.14
14.44	4.93	-11.96	-26.81	-41.48
0.99	0.99	0.99	0.99	0.99
0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00



## APPENDIX C

### Angle and Power Estimation for 90 Percent Reliability

An algorithm developed and implemented by Rosich (1969) permits calculation of the transmitter power required to achieve a given value of circuit reliability or service probability and time availability on HF ionospheric telecommunication systems. The accuracy of this computer program has been demonstrated by direct hand calculation and by comparison of the results with predicted reliabilities and service probabilities for given input power levels. Thus, the accuracy is an implicit function of the original prediction program.

The first page for each distance of 500, 1000, 2000, 3000, 4000, and 5000 km of this appendix summarizes the required transmitter power and arrival angles for hours 1 through 11 UT at four bearings for April, May, and June, 1969. Additional information about the system parameters are contained in section 5 of this report.

Each subsection as identified by distance contains information about the required transmitter power and arrival angle statistics by hour and by bearing combinations. The bearings indicated by 1, 2, 3, and 4 correspond respectively to north, east, south, and west.

TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 500 km.

BEARING (DEG)	HOUR (UT)	April			May			June		
		ARRIVAL ANGLE (DEG)	POWER (DBW)		ARRIVAL ANGLE (DEG)	POWER (DBW)		ARRIVAL ANGLE (DEG)	POWER (DBW)	
0.0	1	63.0	29.0		66.0	31.0		19.0	44.0	
	2	42.0	22.0		46.0	23.0		64.0	37.0	
	3	43.0	21.0		43.0	21.0		43.0	29.0	
	4	45.0	24.0		45.0	24.0		43.0	33.0	
	5	47.0	26.0		46.0	26.0		44.0	34.0	
	6	48.0	28.0		46.0	27.0		44.0	34.0	
	7	48.0	28.0		47.0	27.0		45.0	34.0	
	8	49.0	27.0		47.0	26.0		46.0	34.0	
	9	49.0	27.0		48.0	27.0		46.0	34.0	
	10	49.0	23.0		47.0	23.0		46.0	30.0	
	11	48.0	25.0		46.0	22.0		46.0	23.0	
90.0	1	46.0	27.0		65.0	29.0		73.0	45.0	
	2	42.0	20.0		44.0	20.0		47.0	37.0	
	3	44.0	26.0		44.0	26.0		43.0	35.0	
	4	46.0	30.0		45.0	29.0		43.0	35.0	
	5	47.0	32.0		46.0	31.0		44.0	36.0	
	6	48.0	32.0		47.0	31.0		45.0	36.0	
	7	48.0	33.0		47.0	33.0		46.0	38.0	
	8	49.0	32.0		48.0	32.0		46.0	37.0	
	9	49.0	31.0		48.0	30.0		46.0	36.0	
	10	48.0	27.0		47.0	27.0		46.0	31.0	
	11	47.0	26.0		46.0	24.0		46.0	24.0	
180.0	1	62.0	24.0		65.0	27.0		19.0	40.0	
	2	42.0	18.0		45.0	18.0		63.0	30.0	
	3	43.0	20.0		43.0	20.0		43.0	26.0	
	4	45.0	24.0		45.0	23.0		43.0	25.0	
	5	47.0	27.0		46.0	27.0		44.0	27.0	
	6	48.0	29.0		47.0	28.0		45.0	27.0	
	7	48.0	29.0		47.0	28.0		45.0	28.0	
	8	48.0	28.0		48.0	28.0		46.0	28.0	
	9	49.0	29.0		48.0	29.0		46.0	28.0	
	10	49.0	25.0		47.0	25.0		46.0	24.0	
	11	48.0	24.0		46.0	21.0		45.0	22.0	
270.0	1	63.0	31.0		73.0	33.0		19.0	42.0	
	2	42.0	22.0		47.0	24.0		64.0	36.0	
	3	43.0	21.0		43.0	21.0		43.0	26.0	
	4	45.0	24.0		45.0	24.0		43.0	29.0	
	5	47.0	26.0		46.0	26.0		44.0	29.0	
	6	48.0	28.0		46.0	27.0		45.0	30.0	
	7	48.0	28.0		47.0	27.0		45.0	30.0	
	8	49.0	28.0		48.0	27.0		46.0	29.0	
	9	49.0	28.0		48.0	27.0		46.0	29.0	
	10	49.0	26.0		47.0	25.0		46.0	27.0	
	11	48.0	25.0		47.0	22.0		46.0	24.0	

HOUR 1 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	34.7	44.2	6.6	49.3	461.6	21.5			
2	33.7	64.9	8.1	61.3	128.2	11.3			
3	30.3	48.2	6.9	48.7	441.6	21.0			
4	35.3	22.9	4.8	51.7	550.2	23.5			
1 2	34.2	54.8	7.4	58.3	330.9	18.2			
1 3	32.5	50.9	7.1	49.0	451.7	21.3			
1 4	35.0	33.7	5.8	50.5	507.3	22.5			
2 3	32.0	39.3	7.7	55.0	325.0	18.0			
2 4	34.5	44.6	6.7	56.5	362.6	19.0			
3 4	32.8	41.4	6.5	50.2	498.1	22.3			
1 2 3 4	33.5	48.8	7.0	52.8	421.2	20.5			

HOUR 3 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	23.7	14.2	3.8	43.0	0.0	0.0			
2	25.0	18.0	4.2	43.7	0.2	0.5			
3	22.0	8.0	2.8	43.0	0.0	0.0			
4	22.1	5.6	2.4	43.0	0.0	0.0			
1 2	26.3	23.2	4.8	43.3	0.2	0.5			
1 3	22.8	11.8	3.4	43.0	0.0	0.0			
1 4	23.2	10.1	3.2	43.0	0.0	0.0			
2 3	25.5	25.3	5.0	43.3	0.2	0.5			
2 4	28.8	21.8	4.7	43.3	0.2	0.5			
3 4	22.3	6.4	2.6	43.0	0.0	0.0			
1 2 3 4	24.3	19.1	4.4	43.2	0.1	0.4			

HOUR 5 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	28.1	14.2	3.8	45.7	1.6	1.2			
2	33.0	4.7	2.2	45.7	1.6	1.2			
3	27.0	0.0	0.0	45.7	1.6	1.2			
4	27.0	2.0	1.4	45.7	1.6	1.2			
1 2	30.8	14.1	3.8	45.7	1.6	1.2			
1 3	27.8	7.8	2.8	45.7	1.6	1.2			
1 4	27.8	8.8	3.0	45.7	1.6	1.2			
2 3	30.0	11.3	3.4	45.7	1.6	1.2			
2 4	30.0	12.3	3.5	45.7	1.6	1.2			
3 4	27.0	1.0	1.0	45.7	1.6	1.2			
1 2 3 4	28.9	11.2	3.4	45.7	1.6	1.2			

HOUR 2 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	27.3	46.9	6.8	50.7	91.6	9.6			
2	25.7	64.2	8.0	44.3	4.2	2.1			
3	22.0	32.0	5.7	50.0	86.0	9.3			
4	27.3	38.2	6.2	51.0	88.7	9.4			
1 2	26.5	56.3	7.5	47.5	51.9	7.6			
1 3	24.7	46.6	6.8	50.3	88.9	9.4			
1 4	27.3	42.6	6.5	50.8	90.1	9.5			
2 3	23.8	51.5	7.2	47.2	53.1	7.3			
2 4	26.5	51.9	7.2	47.7	57.6	7.6			
3 4	24.7	42.2	6.5	50.5	87.6	9.4			
1 2 3 4	25.6	50.1	7.1	49.0	75.0	8.7			

HOUR 4 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	27.0	18.0	4.2	44.3	0.9	0.9			
2	31.3	6.9	2.6	44.7	1.6	1.2			
3	24.0	0.1	0.8	44.3	0.9	0.9			
4	25.1	5.6	2.4	44.3	0.9	0.9			
1 2	29.2	17.1	4.1	44.5	1.3	1.1			
1 3	25.5	11.6	3.4	44.3	0.9	0.9			
1 4	25.3	12.2	3.5	44.3	0.9	0.9			
2 3	27.7	17.2	4.1	44.5	1.3	1.1			
2 4	28.5	14.3	3.8	44.5	1.3	1.1			
3 4	24.5	3.8	2.0	44.3	0.9	0.9			
1 2 3 4	27.0	15.2	3.9	44.4	1.1	1.0			

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS			ARRIVAL ANGLE STATISTICS			STANDARD DEVIATION (DEG)		
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)	MEAN ANGLE (DEG)	STANDARD ANGLE (DEG)	ARRIVAL ANGLE (DEG)
1	29.1	9.6	3.1	46.0	2.7	1.6			
2	33.0	4.7	2.2	46.7	1.6	1.2			
3	28.0	0.1	0.8	46.7	1.6	1.2			
4	28.3	1.6	1.2	46.3	1.6	1.2			
1 2	31.3	9.9	3.1	46.3	2.2	1.5			
1 3	28.8	5.8	2.4	46.3	2.2	1.5			
1 4	29.0	6.0	2.4	46.2	2.1	1.8			
2 3	30.5	8.9	3.0	46.7	1.6	1.2			
2 4	30.7	8.6	2.9	46.5	1.6	1.3			
3 4	28.2	1.1	1.1	46.5	1.6	1.3			
1 2 3 4	29.5	8.0	2.8	46.4	1.9	1.4			

TRANS-MITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

HOOR 7 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	20.7	0.6	3.1	46.7	1.6	1.2		
2	36.7	5.6	2.6	47.0	0.7	0.8		
3	28.3	0.2	0.5	46.7	1.6	1.2		
4	28.3	1.6	1.2	46.7	1.6	1.2		
1 2	32.2	13.8	3.7	46.6	1.1	1.1		
1 3	20.0	5.3	2.3	46.7	1.6	1.2		
1 4	20.0	6.0	2.4	46.7	1.6	1.2		
2 3	31.5	12.0	3.6	46.6	1.1	1.1		
2 4	31.5	13.6	3.7	46.6	1.1	1.1		
3 4	28.3	0.0	0.0	46.7	1.6	1.2		
1 2 3 4	30.3	11.0	3.3	46.6	1.4	1.2		

HOOR 0 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	20.3	10.9	3.3	47.7	1.6	1.2		
2	32.3	6.9	2.6	47.7	1.6	1.2		
3	28.7	0.2	0.5	47.7	1.6	1.2		
4	28.0	0.7	0.6	47.7	1.6	1.2		
1 2	30.8	11.1	3.3	47.7	1.6	1.2		
1 3	20.0	5.7	2.6	47.7	1.6	1.2		
1 4	20.7	6.2	2.5	47.7	1.6	1.2		
2 3	30.5	6.9	2.6	47.7	1.6	1.2		
2 4	30.2	8.5	2.9	47.7	1.6	1.2		
3 4	28.3	0.6	0.7	47.7	1.6	1.2		
1 2 3 4	28.6	7.4	2.7	47.7	1.6	1.2		

HOOR 11 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	23.3	1.6	1.2	46.7	0.0	0.9		
2	24.7	0.0	0.0	46.3	0.2	0.5		
3	22.3	1.6	1.2	46.3	1.6	1.2		
4	23.7	1.6	1.2	47.0	0.7	0.8		
1 2	24.0	1.7	1.3	46.5	0.6	0.8		
1 3	22.6	1.6	1.3	46.5	1.3	1.1		
1 4	23.5	1.6	1.3	46.8	0.8	0.9		
2 3	23.5	2.6	1.6	46.3	0.9	0.9		
2 4	24.2	1.5	1.2	46.7	0.6	0.7		
3 4	23.0	2.0	1.4	46.7	1.2	1.1		
1 2 3 4	23.6	2.1	1.4	46.6	0.9	1.0		

TRANS-MITTER DISTANCE OF 500 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

HOOR 10 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	20.0	12.7	3.6	47.3	1.6	1.2		
2	33.7	5.6	2.4	47.7	1.6	1.2		
3	28.0	0.0	0.0	47.3	0.9	0.0		
4	28.0	0.7	0.6	47.7	1.6	1.2		
1 2	31.3	14.6	3.6	47.5	1.6	1.3		
1 3	28.5	6.6	2.6	47.3	1.2	1.1		
1 4	28.5	6.0	2.6	47.5	1.6	1.3		
2 3	30.8	10.8	3.3	47.5	1.3	1.1		
2 4	30.8	11.1	3.3	47.7	1.6	1.2		
3 4	28.0	0.3	0.4	47.5	1.3	1.1		
1 2 3 4	29.7	10.2	3.2	47.5	1.4	1.2		

HOOR 10 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	25.3	10.9	3.3	47.3	1.6	1.2		
2	28.3	3.6	1.9	47.0	0.7	0.8		
3	24.7	0.2	0.5	47.3	1.6	1.2		
4	28.0	0.7	0.6	47.3	1.6	1.2		
1 2	26.8	6.5	3.1	47.2	1.1	1.1		
1 3	25.0	5.7	2.4	47.3	1.6	1.2		
1 4	25.7	5.0	2.4	47.3	1.6	1.2		
2 3	26.5	5.3	2.3	47.2	1.1	1.1		
2 4	27.2	3.5	1.0	47.2	1.1	1.1		
3 4	25.3	0.9	0.9	47.3	1.6	1.2		
1 2 3 4	26.1	5.7	2.4	47.3	1.4	1.2		

HOOR 11 (UT)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	VARIANCE (DB)	MEAN POWER (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	VARIANCE (DEG)	MEAN ANGLE (DEG)
1	23.3	1.6	1.2	46.7	0.0	0.9		
2	24.7	0.0	0.0	46.3	0.2	0.5		
3	22.3	1.6	1.2	46.3	1.6	1.2		
4	23.7	1.6	1.2	47.0	0.7	0.8		
1 2	24.0	1.7	1.3	46.5	0.6	0.8		
1 3	22.6	1.6	1.3	46.5	1.3	1.1		
1 4	23.5	1.6	1.3	46.8	0.8	0.9		
2 3	23.5	2.6	1.6	46.3	0.9	0.9		
2 4	24.2	1.5	1.2	46.7	0.6	0.7		
3 4	23.0	2.0	1.4	46.7	1.2	1.1		
1 2 3 4	23.6	2.1	1.4	46.6	0.9	1.0		

TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 1000 km.

BEARING (DEG)	HOUR (UT)	April			May			June		
		ARRIVAL ANGLE(DEG)	POWER (DBW)		ARRIVAL ANGLE(DEG)	POWER (DBW)		ARRIVAL ANGLE(DEG)	POWER (DBW)	
0.0.	1	56.0	54.0		8.0	57.0		8.0	71.0	
	2	25.0	27.0		47.0	43.0		58.0	59.0	
	3	24.0	25.0		24.0	25.0		44.0	45.0	
	4	25.0	25.0		25.0	24.0		24.0	33.0	
	5	26.0	24.0		25.0	24.0		24.0	33.0	
	6	27.0	24.0		26.0	24.0		24.0	33.0	
	7	27.0	24.0		26.0	24.0		25.0	34.0	
	8	28.0	23.0		27.0	23.0		25.0	32.0	
	9	28.0	23.0		27.0	23.0		25.0	27.0	
	10	28.0	21.0		26.0	20.0		25.0	27.0	
	11	27.0	26.0		26.0	24.0		47.0	38.0	
90.0	1	44.0	40.0		58.0	46.0		8.0	66.0	
	2	23.0	24.0		44.0	34.0		46.0	52.0	
	3	24.0	27.0		24.0	27.0		23.0	35.0	
	4	26.0	31.0		25.0	30.0		24.0	36.0	
	5	27.0	31.0		26.0	30.0		24.0	36.0	
	6	27.0	31.0		26.0	31.0		25.0	37.0	
	7	28.0	32.0		27.0	32.0		26.0	38.0	
	8	28.0	31.0		27.0	31.0		26.0	38.0	
	9	28.0	28.0		27.0	28.0		26.0	34.0	
	10	27.0	24.0		26.0	25.0		25.0	29.0	
	11	26.0	24.0		26.0	24.0		46.0	40.0	
180.0	1	55.0	41.0		8.0	48.0		8.0	59.0	
	2	23.0	18.0		44.0	31.0		55.0	42.0	
	3	20.0	20.0		19.0	19.0		24.0	22.0	
	4	26.0	22.0		25.0	21.0		24.0	20.0	
	5	27.0	24.0		26.0	24.0		24.0	21.0	
	6	27.0	24.0		26.0	24.0		25.0	21.0	
	7	27.0	25.0		27.0	25.0		25.0	22.0	
	8	27.0	25.0		27.0	25.0		26.0	22.0	
	9	28.0	26.0		27.0	26.0		26.0	22.0	
	10	28.0	23.0		27.0	23.0		25.0	19.0	
	11	27.0	22.0		26.0	19.0		25.0	18.0	
270.0	1	8.0	54.0		8.0	59.0		8.0	66.0	
	2	43.0	33.0		57.0	44.0		8.0	51.0	
	3	23.0	20.0		25.0	23.0		44.0	38.0	
	4	25.0	21.0		24.0	21.0		23.0	25.0	
	5	26.0	21.0		25.0	20.0		24.0	24.0	
	6	27.0	24.0		26.0	23.0		25.0	25.0	
	7	27.0	24.0		26.0	24.0		25.0	24.0	
	8	28.0	22.0		27.0	22.0		26.0	23.0	
	9	28.0	22.0		27.0	23.0		26.0	22.0	
	10	28.0	22.0		27.0	22.0		25.0	21.0	
	11	28.0	23.0		26.0	20.0		25.0	20.0	

HOUR 1 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	60.7	54.9	7.4	24.0	512.0	22.6		
2	50.7	123.6	11.1	36.7	443.6	21.1		
3	49.3	54.9	7.4	23.7	490.9	22.2		
4	50.7	24.2	4.9	8.0	0.0	0.0		
1 2	55.7	114.2	10.7	30.3	517.9	22.8		
1 3	55.0	87.0	9.3	23.8	501.5	22.4		
1 4	60.2	38.8	6.3	16.0	320.0	17.9		
2 3	50.0	88.7	9.5	30.2	509.5	22.6		
2 4	55.2	94.1	9.7	22.3	427.2	20.7		
3 4	54.5	66.3	8.1	15.8	308.8	17.8		
1 2 3 4	55.1	90.6	9.5	23.1	464.9	21.6		

HOUR 3 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	31.7	88.9	9.4	30.7	88.9	9.4		
2	29.7	14.2	3.8	23.7	0.2	0.8		
3	20.3	1.6	1.2	24.0	0.0	0.0		
4	27.0	62.0	7.9	30.7	89.8	9.5		
1 2	30.7	52.6	7.2	27.2	56.8	7.5		
1 3	26.0	77.3	8.8	27.3	55.6	7.5		
1 4	28.3	88.9	9.0	30.7	89.2	9.4		
2 3	25.0	29.7	5.4	23.8	0.1	0.4		
2 4	28.3	38.9	6.3	27.2	57.1	7.6		
3 4	23.7	42.9	6.5	27.3	55.9	7.5		
1 2 3 4	27.2	60.0	7.7	27.3	56.4	7.5		

HOUR 5 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	27.0	18.0	4.2	25.0	0.7	0.8		
2	32.3	6.9	2.6	25.7	1.8	1.2		
3	23.0	2.0	1.4	25.7	1.6	1.2		
4	21.7	2.9	1.7	25.0	0.7	0.8		
1 2	29.7	19.6	4.4	28.3	1.2	1.1		
1 3	25.0	14.0	3.7	25.3	1.2	1.1		
1 4	23.3	17.6	4.2	25.0	0.7	0.8		
2 3	27.7	26.2	5.1	25.7	1.6	1.2		
2 4	27.0	33.3	5.8	25.3	1.2	1.1		
3 4	22.3	2.9	1.7	25.3	1.2	1.1		
1 2 3 4	26.0	24.7	5.0	25.3	1.2	1.1		

HOUR 2 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	43.0	170.7	13.1	43.3	188.2	13.7		
2	36.7	134.2	11.6	37.7	108.2	10.4		
3	30.3	96.2	9.8	40.7	176.2	13.3		
4	42.7	54.9	7.4	36.0	424.7	20.6		
1 2	39.8	162.5	12.7	40.5	156.3	12.5		
1 3	36.7	173.6	13.2	42.0	184.0	13.6		
1 4	42.8	112.8	10.6	38.7	316.9	17.9		
2 3	33.5	125.3	11.2	39.2	144.5	12.0		
2 4	39.7	103.6	10.2	36.8	287.1	16.3		
3 4	35.5	113.6	10.7	38.3	305.9	17.8		
1 2 3 4	38.2	140.8	11.9	39.4	232.2	15.2		

HOUR 4 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	27.3	16.2	4.0	24.7	0.2	0.5		
2	32.3	6.9	2.6	25.0	0.7	0.8		
3	21.0	0.7	0.8	25.0	0.7	0.8		
4	22.3	3.6	1.9	24.0	0.7	0.8		
1 2	29.8	17.8	4.2	24.8	0.5	0.7		
1 3	24.2	19.3	4.3	24.8	0.5	0.7		
1 4	22.8	16.1	4.0	24.3	0.6	0.7		
2 3	25.7	35.9	6.0	25.0	0.7	0.8		
2 4	27.3	30.2	5.5	24.5	0.9	1.0		
3 4	21.7	2.6	1.6	24.5	0.9	1.0		
1 2 3 4	25.8	26.9	5.2	24.7	0.7	0.8		

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DB)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	27.0	18.0	4.2	25.7	1.6	1.2		
2	33.0	8.0	2.8	28.0	0.7	0.8		
3	23.0	2.0	1.4	26.0	0.7	0.8		
4	24.0	0.7	0.8	26.0	0.7	0.8		
1 2	30.0	22.0	4.7	26.8	1.1	1.1		
1 3	25.0	14.0	3.7	25.8	1.1	1.1		
1 4	25.5	11.6	3.4	25.8	1.1	1.1		
2 3	28.0	30.0	5.8	28.0	0.7	0.8		
2 4	28.5	24.6	5.0	28.0	0.7	0.8		
3 4	23.5	1.8	1.3	28.0	0.7	0.8		
1 2 3 4	26.8	22.4	4.7	28.9	0.9	1.0		

HOUR 7 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	27.3	22.2	4.7		26.0	0.7	0.8	
2	34.0	6.0	2.6		27.0	0.7	0.8	
3	25.0	2.0	1.4		26.3	0.9	0.9	
4	24.0	0.0	0.0		26.0	0.7	0.8	
1 2	30.7	26.2	5.1		26.5	0.9	1.0	
1 3	28.1	14.9	3.9		26.2	0.8	0.9	
1 4	28.1	13.9	3.7		26.0	0.7	0.8	
2 3	29.0	30.0	5.5		26.7	0.9	0.9	
2 4	29.0	29.0	6.4		26.5	0.9	1.0	
3 4	28.0	1.0	1.0		26.2	0.8	0.9	
1 2 3 4	27.3	24.7	5.0		26.3	0.9	0.9	

HOUR 9 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	26.0	18.0	4.2		26.7	1.6	1.2	
2	30.0	8.0	2.8		27.0	0.7	0.8	
3	24.7	3.6	1.9		27.0	0.7	0.8	
4	22.3	0.2	0.5		27.0	0.7	0.8	
1 2	29.0	17.0	4.1		26.8	1.1	1.1	
1 3	28.3	11.2	3.3		26.8	1.1	1.1	
1 4	24.2	12.5	3.5		26.8	1.1	1.1	
2 3	27.3	12.9	3.6		27.0	0.7	0.8	
2 4	26.2	18.8	4.3		27.0	0.7	0.8	
3 4	23.3	3.3	1.8		27.0	0.7	0.8	
1 2 3 4	25.9	15.2	3.9		26.9	0.9	1.0	

HOUR 11 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	29.3	38.2	6.2		33.3	93.6	9.7	
2	29.3	56.9	7.5		32.7	86.9	9.4	
3	19.7	2.9	1.7		26.0	0.7	0.8	
4	21.0	2.0	1.4		26.3	1.6	1.2	
1 2	29.3	47.6	6.9		33.0	91.3	9.6	
1 3	24.5	43.9	6.6		29.7	60.6	7.6	
1 4	25.2	37.5	6.1		29.8	89.6	7.7	
2 3	24.5	33.3	7.3		29.3	55.9	7.5	
2 4	28.2	46.8	6.8		29.5	55.3	7.4	
3 4	20.3	2.9	1.7		26.2	1.1	1.1	
1 2 3 4	24.8	45.5	6.7		29.6	57.9	7.6	

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	26.0	18.0	4.2		26.7	1.6	1.2	
2	33.3	10.9	3.3		27.0	0.7	0.8	
3	24.0	2.0	1.4		26.7	0.2	0.8	
4	22.3	0.2	0.5		27.0	0.7	0.8	
1 2	29.7	27.9	5.3		26.8	1.1	1.1	
1 3	29.0	11.0	3.3		26.7	0.9	0.9	
1 4	24.2	12.5	3.5		26.8	1.1	1.1	
2 3	26.1	28.2	5.3		26.8	0.5	0.7	
2 4	27.6	38.8	6.0		27.0	0.7	0.8	
3 4	23.2	1.8	1.3		26.6	0.5	0.7	
1 2 3 4	25.4	25.4	5.0		26.8	0.8	0.9	

HOUR 10 (UT)  
 TRANSMITTER DISTANCE OF 1000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	28.7	9.6	3.1		26.3	1.6	1.2	
2	26.0	4.7	2.2		26.0	0.7	0.8	
3	21.7	3.6	1.9		26.7	1.6	1.2	
4	21.7	0.2	0.5		26.7	1.6	1.2	
1 2	24.3	9.9	3.1		26.2	1.1	1.1	
1 3	22.2	6.8	2.6		26.5	1.6	1.3	
1 4	22.2	5.1	2.3		26.8	1.6	1.3	
2 3	23.8	8.8	3.0		26.3	1.2	1.1	
2 4	23.8	7.1	2.7		26.3	1.2	1.1	
3 4	21.7	1.9	1.4		26.7	1.6	1.2	
1 2 3 4	23.0	7.7	2.6		26.4	1.4	1.2	

# TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 2000 km.

BEARING (DEG)	HOUR (UT)	April		May		June	
		ARRIVAL ANGLE(DEG)	POWER (DBW)	ARRIVAL ANGLE(DEG)	POWER (DBW)	ARRIVAL ANGLE(DEG)	POWER (DBW)
0.0	1	1.0	81.0	1.0	92.0	1.0	99.0
	2	25.0	51.0	1.0	80.0	1.0	94.0
	3	10.0	41.0	24.0	47.0	37.0	66.0
	4	11.0	41.0	11.0	38.0	10.0	41.0
	5	11.0	46.0	11.0	39.0	10.0	42.0
	6	12.0	45.0	11.0	39.0	10.0	43.0
	7	12.0	45.0	11.0	39.0	11.0	43.0
	8	12.0	33.0	11.0	28.0	11.0	33.0
	9	12.0	33.0	11.0	28.0	11.0	33.0
	10	12.0	33.0	11.0	28.0	11.0	31.0
	11	12.0	30.0	26.0	48.0	38.0	68.0
90.0	1	35.0	45.0	1.0	67.0	1.0	89.0
	2	10.0	33.0	24.0	38.0	36.0	60.0
	3	11.0	36.0	11.0	36.0	10.0	39.0
	4	12.0	37.0	11.0	37.0	10.0	40.0
	5	12.0	37.0	11.0	37.0	11.0	42.0
	6	12.0	38.0	12.0	38.0	11.0	43.0
	7	12.0	37.0	12.0	37.0	11.0	43.0
	8	12.0	36.0	12.0	36.0	11.0	41.0
	9	12.0	32.0	12.0	33.0	11.0	36.0
	10	12.0	33.0	11.0	31.0	25.0	39.0
	11	11.0	29.0	38.0	50.0	1.0	66.0
180.0	1	1.0	67.0	1.0	78.0	1.0	85.0
	2	10.0	25.0	35.0	46.0	1.0	58.0
	3	10.0	24.0	10.0	24.0	10.0	24.0
	4	11.0	24.0	11.0	24.0	10.0	24.0
	5	12.0	27.0	11.0	26.0	11.0	24.0
	6	12.0	27.0	12.0	26.0	11.0	24.0
	7	12.0	28.0	12.0	27.0	11.0	24.0
	8	12.0	28.0	12.0	27.0	11.0	24.0
	9	12.0	29.0	12.0	28.0	11.0	23.0
	10	12.0	27.0	12.0	26.0	11.0	22.0
	11	12.0	22.0	11.0	24.0	11.0	24.0
270.0	1	1.0	90.0	1.0	99.0	1.0	99.0
	2	1.0	64.0	1.0	79.0	1.0	88.0
	3	10.0	25.0	37.0	48.0	1.0	65.0
	4	11.0	25.0	11.0	25.0	24.0	31.0
	5	11.0	25.0	11.0	24.0	10.0	25.0
	6	12.0	25.0	11.0	25.0	11.0	25.0
	7	12.0	25.0	11.0	25.0	11.0	25.0
	8	12.0	25.0	12.0	25.0	11.0	25.0
	9	12.0	24.0	12.0	25.0	11.0	25.0
	10	12.0	24.0	12.0	23.0	11.0	24.0
	11	12.0	24.0	12.0	23.0	11.0	24.0

HOUR 1 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	90.7	54.9	7.4	1.0	0.0	0.0	0.0	0.0
2	61.0	322.7	18.0	12.3	256.9	16.0	0.0	0.0
3	76.7	94.9	7.4	1.0	0.0	0.0	0.0	0.0
4	96.0	18.0	4.2	1.0	0.0	0.0	0.0	0.0
1 2	78.9	328.8	18.1	6.7	160.4	12.7	0.0	0.0
1 3	83.7	103.9	10.2	1.0	0.0	0.0	0.0	0.0
1 4	93.3	43.6	6.6	1.0	0.0	0.0	0.0	0.0
2 3	71.8	212.1	14.6	6.7	160.6	12.7	0.0	0.0
2 4	81.5	380.6	19.5	6.7	160.6	12.7	0.0	0.0
3 4	84.3	129.9	11.4	1.0	0.0	0.0	0.0	0.0
1 2 3 4	82.6	243.4	15.6	3.8	89.3	9.4	0.0	0.0

HOUR 3 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	51.3	113.6	10.7	23.7	121.6	11.0	0.0	0.0
2	37.0	2.0	1.4	10.7	0.2	0.8	0.0	0.0
3	24.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0
4	46.0	288.7	16.4	16.0	234.0	15.3	0.0	0.0
1 2	44.2	109.1	10.4	17.2	103.1	10.2	0.0	0.0
1 3	37.7	243.6	15.6	16.8	107.5	10.4	0.0	0.0
1 4	48.7	198.2	14.1	19.8	192.5	13.9	0.0	0.0
2 3	30.5	43.3	6.6	10.3	0.2	0.8	0.0	0.0
2 4	41.5	155.6	12.5	13.3	124.2	11.1	0.0	0.0
3 4	35.0	255.3	16.0	13.0	126.0	11.2	0.0	0.0
1 2 3 4	39.6	203.2	14.3	15.1	118.9	10.9	0.0	0.0

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	42.3	8.2	2.9	10.7	0.2	0.8	0.0	0.0
2	38.7	8.6	2.4	11.3	0.2	0.8	0.0	0.0
3	25.7	1.6	1.2	11.3	0.2	0.8	0.0	0.0
4	24.7	0.2	0.5	10.7	0.2	0.8	0.0	0.0
1 2	40.8	10.3	3.2	11.0	0.3	0.6	0.0	0.0
1 3	34.0	74.3	8.6	11.0	0.3	0.6	0.0	0.0
1 4	33.5	82.3	9.1	10.7	0.2	0.5	0.0	0.0
2 3	32.2	45.8	6.8	11.3	0.2	0.5	0.0	0.0
2 4	31.7	51.9	7.2	11.0	0.3	0.6	0.0	0.0
3 4	25.2	1.1	1.1	11.0	0.3	0.6	0.0	0.0
1 2 3 4	32.8	64.5	8.0	11.0	0.3	0.6	0.0	0.0

HOUR 2 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	75.0	320.7	17.9	9.0	128.0	11.3	0.0	0.0
2	43.7	137.6	11.7	23.3	112.9	10.6	0.0	0.0
3	43.0	186.0	13.6	15.3	206.9	14.4	0.0	0.0
4	77.0	98.0	9.9	1.0	0.0	0.0	0.0	0.0
1 2	59.3	474.6	21.8	16.2	171.8	13.1	0.0	0.0
1 3	59.0	509.3	22.6	12.2	177.5	13.3	0.0	0.0
1 4	76.0	210.3	14.5	5.0	80.0	8.9	0.0	0.0
2 3	43.3	161.9	12.7	19.3	175.9	13.3	0.0	0.0
2 4	60.3	395.6	19.9	12.2	181.1	13.5	0.0	0.0
3 4	60.0	431.0	20.8	8.2	194.8	12.4	0.0	0.0
1 2 3 4	59.7	452.9	21.3	12.2	179.3	13.4	0.0	0.0

HOUR 4 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	40.0	2.0	1.4	10.7	0.2	0.8	0.0	0.0
2	38.0	2.0	1.4	11.0	0.7	0.8	0.0	0.0
3	24.0	0.0	0.0	10.7	0.2	0.5	0.0	0.0
4	27.0	8.0	2.8	15.3	37.6	6.1	0.0	0.0
1 2	39.0	3.0	1.7	10.8	0.5	0.7	0.0	0.0
1 3	32.0	65.0	8.1	10.7	0.2	0.5	0.0	0.0
1 4	33.5	47.3	6.9	13.0	24.3	4.9	0.0	0.0
2 3	31.0	50.0	7.1	10.8	0.5	0.7	0.0	0.0
2 4	32.5	35.3	5.9	13.2	23.8	4.9	0.0	0.0
3 4	25.5	6.3	2.8	13.0	24.3	4.9	0.0	0.0
1 2 3 4	32.3	50.2	7.1	11.9	13.6	3.7	0.0	0.0

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (08#)	STANDARD DEVIATION (08)	MEAN ANGLE (050)	STANDARD DEVIATION (050)	MEAN ANGLE (050)	VARIANCE (050)	STANDARD DEVIATION (050)	STANDARD DEVIATION (050)
1	42.3	6.2	2.5	11.0	0.7	0.8	0.0	0.0
2	39.7	8.6	2.4	11.7	0.2	0.5	0.0	0.0
3	28.7	1.6	1.2	11.7	0.2	0.8	0.0	0.0
4	25.0	0.0	0.0	11.3	0.2	0.5	0.0	0.0
1 2	41.0	7.7	2.8	11.3	0.6	0.7	0.0	0.0
1 3	34.0	73.3	8.6	11.3	0.6	0.7	0.0	0.0
1 4	33.7	78.2	8.8	11.2	0.5	0.7	0.0	0.0
2 3	32.7	52.6	7.2	11.7	0.2	0.8	0.0	0.0
2 4	32.3	56.6	7.8	11.5	0.3	0.8	0.0	0.0
3 4	25.3	0.9	0.9	11.8	0.3	0.5	0.0	0.0
1 2 3 4	33.2	65.6	8.1	11.4	0.4	0.6	0.0	0.0

TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

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TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)		MEAN POWER (DBM)	VARIANCE	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	42.3	6.2	2.5	11.3	0.2	0.5	11.3	0.2	0.5	40.7	240.9	15.5	25.3	112.9	10.6	10.6	10.6
2	38.7	5.6	2.4	11.7	0.2	0.5	11.7	0.2	0.5	40.3	229.6	15.2	16.7	244.2	15.6	15.6	15.6
3	26.3	2.9	1.7	11.7	0.2	0.5	11.7	0.2	0.5	23.3	0.9	0.9	11.3	0.2	0.5	0.5	0.5
4	25.0	0.0	0.0	11.3	0.2	0.5	11.7	0.2	0.5	23.7	0.2	0.5	11.7	0.2	0.5	0.5	0.5
1 2	40.5	9.3	3.0	11.5	0.3	0.5	11.5	0.3	0.5	40.5	235.3	15.3	21.0	197.3	14.0	14.0	14.0
1 3	39.3	68.6	8.3	11.5	0.3	0.5	11.5	0.3	0.5	36.0	281.3	16.8	18.3	105.6	10.3	10.3	10.3
1 4	33.7	78.2	8.8	11.3	0.2	0.5	11.5	0.3	0.5	36.2	276.8	16.6	18.5	103.3	10.2	10.2	10.2
2 3	32.5	42.3	6.5	11.7	0.2	0.5	11.7	0.2	0.5	39.8	271.5	16.5	14.0	139.3	11.4	11.4	11.4
2 4	31.8	49.5	7.0	11.5	0.3	0.5	11.7	0.2	0.5	36.0	267.0	16.3	14.2	128.5	11.3	11.3	11.3
3 4	25.7	1.9	1.4	11.5	0.3	0.5	11.7	0.2	0.5	23.5	0.6	0.8	11.5	0.3	0.5	0.5	0.5
1 2 3 4	33.1	60.6	7.8	11.5	0.3	0.5	11.6	0.2	0.5	36.0	274.2	16.6	16.3	121.4	11.0	11.0	11.0

TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

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(APRIL, MAY, JUNE)

TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

TRANSMITTER DISTANCE OF 2001 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)		MEAN POWER (DBM)	VARIANCE	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)
1	31.3	5.6	2.4	11.3	0.2	0.5	11.3	0.2	0.5	30.7	4.2	2.1	11.3	0.2	0.5	0.5	0.5
2	37.7	5.6	2.4	11.7	0.2	0.5	11.7	0.2	0.5	39.3	11.6	3.4	16.0	40.7	6.4	6.4	6.4
3	26.0	4.7	2.2	11.7	0.2	0.5	11.7	0.2	0.5	25.7	1.6	1.2	11.7	0.2	0.5	0.5	0.5
4	25.0	0.0	0.0	11.7	0.2	0.5	11.7	0.2	0.5	23.7	0.2	0.5	11.7	0.2	0.5	0.5	0.5
1 2	34.5	15.6	3.9	11.5	0.3	0.5	11.5	0.3	0.5	32.5	11.3	3.4	13.7	25.9	5.1	5.1	5.1
1 3	28.7	12.2	3.5	11.5	0.3	0.5	11.5	0.3	0.5	28.2	9.1	3.0	11.5	0.3	0.5	0.5	0.5
1 4	28.2	12.8	3.6	11.5	0.3	0.5	11.5	0.3	0.5	27.2	14.5	3.8	11.5	0.3	0.5	0.5	0.5
2 3	31.8	39.1	6.3	11.7	0.2	0.5	11.7	0.2	0.5	30.0	25.3	5.0	13.8	26.1	5.0	5.0	5.0
2 4	31.3	42.9	6.5	11.7	0.2	0.5	11.7	0.2	0.5	29.0	34.3	5.9	13.8	25.1	5.0	5.0	5.0
3 4	25.5	2.6	1.6	11.7	0.2	0.5	11.7	0.2	0.5	24.7	1.9	1.4	11.7	0.2	0.5	0.5	0.5
1 2 3 4	30.0	29.3	5.4	11.6	0.2	0.5	11.6	0.2	0.5	28.6	21.9	4.7	12.7	14.1	3.7	3.7	3.7

# TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 3000 km.

BEARING (DEG)	HOUR (UT)	April		May		June	
		ARRIVAL ANGLE(DEG)	POWER (DBW)	ARRIVAL ANGLE(DEG)	POWER (DBW)	ARRIVAL ANGLE(DEG)	POWER (DBW)
0.0	1	3.0	97.0	3.0	99.0	3.0	99.0
	2	26.0	63.0	4.0	94.0	3.0	99.0
	3	15.0	46.0	25.0	53.0	4.0	88.0
	4	16.0	46.0	15.0	36.0	16.0	46.0
	5	16.0	46.0	16.0	40.0	15.0	45.0
	5	17.0	46.0	16.0	40.0	15.0	42.0
	7	17.0	46.0	16.0	40.0	15.0	41.0
	8	17.0	38.0	16.0	35.0	15.0	37.0
	9	17.0	38.0	16.0	35.0	15.0	39.0
	10	17.0	38.0	16.0	37.0	16.0	46.0
	11	17.0	36.0	26.0	63.0	4.0	97.0
90.0	1	14.0	37.0	15.0	47.0	4.0	85.0
	2	15.0	36.0	15.0	38.0	15.0	42.0
	3	16.0	39.0	16.0	39.0	15.0	36.0
	4	17.0	42.0	16.0	40.0	15.0	38.0
	5	18.0	43.0	17.0	41.0	16.0	40.0
	6	18.0	44.0	17.0	42.0	16.0	42.0
	7	18.0	42.0	17.0	41.0	16.0	42.0
	8	18.0	38.0	17.0	38.0	16.0	37.0
	9	17.0	35.0	17.0	36.0	16.0	34.0
	10	17.0	30.0	16.0	35.0	16.0	42.0
	11	16.0	38.0	28.0	59.0	4.0	94.0
180.0	1	4.0	84.0	3.0	99.0	3.0	99.0
	2	14.0	30.0	24.0	46.0	4.0	68.0
	3	15.0	30.0	15.0	30.0	14.0	30.0
	4	16.0	31.0	16.0	31.0	15.0	30.0
	5	17.0	34.0	17.0	33.0	16.0	32.0
	6	17.0	34.0	17.0	33.0	16.0	33.0
	7	17.0	35.0	17.0	34.0	16.0	34.0
	8	16.0	35.0	17.0	34.0	16.0	35.0
	9	17.0	35.0	17.0	34.0	16.0	36.0
	10	17.0	34.0	17.0	33.0	16.0	34.0
	11	17.0	31.0	16.0	32.0	15.0	33.0
270.0	1	3.0	99.0	3.0	99.0	3.0	99.0
	2	4.0	96.0	3.0	99.0	3.0	99.0
	3	14.0	42.0	4.0	80.0	4.0	97.0
	4	15.0	32.0	15.0	36.0	15.0	44.0
	5	16.0	32.0	16.0	32.0	15.0	32.0
	6	17.0	34.0	16.0	32.0	15.0	32.0
	7	17.0	34.0	16.0	32.0	16.0	32.0
	8	18.0	34.0	17.0	32.0	16.0	32.0
	9	18.0	32.0	17.0	31.0	16.0	31.0
	10	18.0	32.0	17.0	31.0	16.0	31.0
	11	18.0	32.0	17.0	31.0	16.0	31.0

HOUR 1 (UT)  
 TRANSMITTER DISTANCE OF 3000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	FROM RECEIVER	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	FROM RECEIVER	MEAN POWER (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	FROM RECEIVER	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	FROM RECEIVER		MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)				
1	98.3	0.8	0.0	3.0	0.0	0.0	62.3	337.6	18.4	14.7	73.6	8.6	1	43.7	6.9	2.6	15.7	0.2	0.5							
2	95.3	427.6	20.7	11.0	26.7	5.0	38.0	2.0	1.4	15.7	0.2	0.8	2	41.3	1.6	1.2	17.0	0.7	0.8							
3	94.0	50.0	7.1	3.3	0.2	0.5	30.0	0.0	0.0	14.7	0.2	0.5	3	32.0	0.7	0.8	16.7	0.2	0.5							
4	99.0	0.0	0.0	0.0	0.0	0.0	73.0	528.7	23.0	7.3	22.2	4.7	4	32.0	0.0	0.0	15.7	0.2	0.8							
1 2	77.3	655.2	25.6	7.0	28.3	5.3	50.2	317.8	17.8	15.2	37.1	6.1	1 2	42.5	5.6	2.4	16.3	0.9	0.9							
1 3	96.2	30.1	5.5	3.2	0.1	0.4	46.2	430.1	20.7	14.7	36.9	6.1	1 3	38.3	32.2	5.7	16.2	0.5	0.7							
1 4	98.7	0.6	0.7	3.0	0.0	0.0	67.7	461.6	21.5	11.0	61.3	7.8	1 4	37.8	37.5	6.1	15.7	0.2	0.5							
2 3	75.2	593.5	24.4	7.2	27.1	5.2	36.0	17.0	4.1	15.2	0.5	0.7	2 3	37.2	18.5	4.3	16.8	0.5	0.7							
2 4	77.7	686.8	25.9	7.0	28.3	5.3	55.5	971.6	23.9	11.5	28.6	5.3	2 4	38.7	22.6	4.7	16.3	0.9	0.9							
3 4	96.5	31.3	5.6	3.2	0.1	0.4	51.5	726.6	27.0	11.0	24.7	5.0	3 4	32.5	0.6	0.8	16.2	0.5	0.7							
1 2 3 4	86.9	435.1	20.9	5.1	17.9	4.2	50.8	522.6	22.9	13.1	35.2	5.9	1 2 3 4	37.5	28.1	5.3	16.3	0.7	0.8							

HOUR 3 (UT)  
 TRANSMITTER DISTANCE OF 3000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS						
	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)					
1	98.3	0.9	0.0	3.0	0.0	0.0	1	62.3	337.6	18.4	14.7	73.6	8.6	1	43.7	6.9	2.6	15.7	0.2	0.5
2	55.3	427.6	20.7	11.0	26.7	5.0	2	36.0	2.0	1.4	15.7	0.2	0.8	2	41.3	1.6	1.2	17.0	0.7	0.8
3	94.0	50.0	7.1	3.3	0.2	0.5	3	30.0	0.0	0.0	14.7	0.2	0.5	3	33.0	0.7	0.8	16.7	0.2	0.5
4	99.0	0.0	0.0	3.0	0.0	0.0	4	73.0	528.7	23.0	7.3	22.2	4.7	4	32.0	0.0	0.0	15.7	0.2	0.8
1 2	77.3	655.2	25.6	7.0	28.3	5.3	1 2	50.2	317.8	17.8	15.2	37.1	6.1	1 2	42.5	5.6	2.4	16.3	0.9	0.9
1 3	96.2	30.1	5.5	3.2	0.1	0.4	1 3	46.2	430.1	20.7	14.7	36.9	6.1	1 3	38.3	32.2	5.7	16.2	0.5	0.7
1 4	98.7	0.6	0.7	3.0	0.0	0.0	1 4	67.7	461.6	21.5	11.0	61.3	7.8	1 4	37.8	37.5	6.1	15.7	0.2	0.5
2 3	75.2	593.5	24.4	7.2	27.1	5.2	2 3	36.0	17.0	4.1	15.2	0.5	0.7	2 3	37.2	18.5	4.3	16.8	0.5	0.7
2 4	77.7	668.8	25.9	7.0	28.3	5.3	2 4	55.5	571.6	23.9	11.5	28.6	5.3	2 4	36.7	22.6	4.7	16.3	0.9	0.9
3 4	96.5	31.3	5.6	3.2	0.1	0.4	3 4	51.5	726.6	27.0	11.0	24.7	5.0	3 4	32.5	0.6	0.8	16.2	0.5	0.7
1 2 3 4	86.9	435.1	20.9	5.1	17.9	4.2	1 2 3 4	50.8	522.6	22.9	13.1	35.2	5.9	1 2 3 4	37.5	28.1	5.3	16.3	0.7	0.8

HOUR 5 (UT)  
 TRANSMITTER DISTANCE OF 3000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS						
	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)					
1	98.3	0.9	0.0	3.0	0.0	0.0	1	62.3	337.6	18.4	14.7	73.6	8.6	1	43.7	6.9	2.6	15.7	0.2	0.5
2	55.3	427.6	20.7	11.0	26.7	5.0	2	36.0	2.0	1.4	15.7	0.2	0.8	2	41.3	1.6	1.2	17.0	0.7	0.8
3	94.0	50.0	7.1	3.3	0.2	0.5	3	30.0	0.0	0.0	14.7	0.2	0.5	3	33.0	0.7	0.8	16.7	0.2	0.5
4	99.0	0.0	0.0	3.0	0.0	0.0	4	73.0	528.7	23.0	7.3	22.2	4.7	4	32.0	0.0	0.0	15.7	0.2	0.8
1 2	77.3	655.2	25.6	7.0	28.3	5.3	1 2	50.2	317.8	17.8	15.2	37.1	6.1	1 2	42.5	5.6	2.4	16.3	0.9	0.9
1 3	96.2	30.1	5.5	3.2	0.1	0.4	1 3	46.2	430.1	20.7	14.7	36.9	6.1	1 3	38.3	32.2	5.7	16.2	0.5	0.7
1 4	98.7	0.6	0.7	3.0	0.0	0.0	1 4	67.7	461.6	21.5	11.0	61.3	7.8	1 4	37.8	37.5	6.1	15.7	0.2	0.5
2 3	75.2	593.5	24.4	7.2	27.1	5.2	2 3	36.0	17.0	4.1	15.2	0.5	0.7	2 3	37.2	18.5	4.3	16.8	0.5	0.7
2 4	77.7	668.8	25.9	7.0	28.3	5.3	2 4	55.5	571.6	23.9	11.5	28.6	5.3	2 4	36.7	22.6	4.7	16.3	0.9	0.9
3 4	96.5	31.3	5.6	3.2	0.1	0.4	3 4	51.5	726.6	27.0	11.0	24.7	5.0	3 4	32.5	0.6	0.8	16.2	0.5	0.7
1 2 3 4	86.9	435.1	20.9	5.1	17.9	4.2	1 2 3 4	50.8	522.6	22.9	13.1	35.2	5.9	1 2 3 4	37.5	28.1	5.3	16.3	0.7	0.8

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 3000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS				BEARING	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS						
	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)		MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)	MEAN POWER (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	STANDARD DEVIATION (DEG)					
1	98.3	0.9	0.0	3.0	0.0	0.0	1	62.3	337.6	18.4	14.7	73.6	8.6	1	43.7	6.9	2.6	15.7	0.2	0.5
2	55.3	427.6	20.7	11.0	26.7	5.0	2	36.0	2.0	1.4	15.7	0.2	0.8	2	41.3	1.6	1.2	17.0	0.7	0.8
3	94.0	50.0	7.1	3.3	0.2	0.5	3	30.0	0.0	0.0	14.7	0.2	0.5	3	33.0	0.7	0.8	16.7	0.2	0.5
4	99.0	0.0	0.0	3.0	0.0	0.0	4	73.0	528.7	23.0	7.3	22.2	4.7	4	32.0	0.0	0.0	15.7	0.2	0.8
1 2	77.3	655.2	25.6	7.0	28.3	5.3	1 2	50.2	317.8	17.8	15.2	37.1	6.1	1 2	42.5	5.6	2.4	16.3	0.9	0.9
1 3	96.2	30.1	5.5	3.2	0.1	0.4	1 3	46.2	430.1	20.7	14.7	36.9	6.1	1 3	38.3	32.2	5.7	16.2	0.5	0.7
1 4	98.7	0.6	0.7	3.0	0.0	0.0	1 4	67.7	461.6	21.5	11.0	61.3	7.8	1 4	37.8	37.5	6.1	15.7	0.2	0.5
2 3	75.2	593.5	24.4	7.2	27.1	5.2	2 3	36.0	17.0	4.1	15.2	0.5	0.7	2 3	37.2	18.5	4.3	16.8	0.5	0.7
2 4	77.7	668.8	25.9	7.0	28.3	5.3	2 4	55.5	571.6	23.9	11.5	28.6	5.3	2 4	36.7	22.6	4.7	16.3	0.9	0.9
3 4	96.5	31.3	5.6	3.2	0.1	0.4	3 4	51.5	726.6	27.0	11.0	24.7	5.0	3 4	32.5	0.6	0.8	16.2	0.5	0.7
1 2 3 4	86.9	435.1	20.9	5.1	17.9	4.2	1 2 3 4	50.8	522.6	22.9	13.1	35.2	5.9	1 2 3 4	37.5	28.1	5.3	16.3	0.7	0.8



# TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 4000 km.

BEARING (DEG)	HOUR (UT)	April			May			June		
		ARRIVAL ANGLE(DEG)	POWER (DBW)		ARRIVAL ANGLE(DEG)	POWER (DBW)		ARRIVAL ANGLE(DEG)	POWER (DBW)	
0.0	1	1.0	99.0		1.0	99.0		1.0	99.0	
	2	1.0	83.0		1.0	99.0		1.0	99.0	
	3	1.0	45.0		1.0	92.0		1.0	99.0	
	4	11.0	44.0		10.0	50.0		20.0	69.0	
	5	11.0	44.0		11.0	44.0		10.0	55.0	
	6	11.0	44.0		11.0	42.0		10.0	51.0	
	7	12.0	44.0		11.0	41.0		10.0	49.0	
	8	12.0	38.0		11.0	37.0		10.0	46.0	
	9	12.0	38.0		11.0	39.0		10.0	50.0	
	10	12.0	39.0		11.0	45.0		20.0	64.0	
	11	11.0	37.0		1.0	91.0		1.0	99.0	
90.0	1	10.0	39.0		10.0	48.0		10.0	57.0	
	2	11.0	39.0		11.0	39.0		10.0	40.0	
	3	11.0	40.0		11.0	40.0		10.0	35.0	
	4	12.0	43.0		11.0	40.0		11.0	37.0	
	5	12.0	44.0		11.0	41.0		11.0	39.0	
	6	12.0	44.0		12.0	42.0		11.0	41.0	
	7	12.0	39.0		12.0	39.0		11.0	36.0	
	8	12.0	36.0		12.0	36.0		11.0	34.0	
	9	12.0	35.0		11.0	34.0		11.0	36.0	
	10	11.0	35.0		11.0	46.0		19.0	61.0	
	11	10.0	53.0		1.0	99.0		1.0	99.0	
180.0	1	1.0	97.0		1.0	99.0		1.0	99.0	
	2	10.0	27.0		24.0	38.0		24.0	46.0	
	3	10.0	26.0		10.0	26.0		10.0	26.0	
	4	11.0	26.0		11.0	26.0		10.0	26.0	
	5	12.0	29.0		12.0	29.0		11.0	29.0	
	6	11.0	29.0		12.0	29.0		11.0	27.0	
	7	11.0	30.0		12.0	30.0		11.0	29.0	
	8	11.0	30.0		11.0	30.0		11.0	31.0	
	9	11.0	30.0		11.0	30.0		11.0	33.0	
	10	11.0	30.0		11.0	30.0		11.0	31.0	
	11	11.0	26.0		11.0	26.0		10.0	29.0	
270.0	1	1.0	99.0		1.0	99.0		1.0	99.0	
	2	1.0	99.0		1.0	99.0		1.0	99.0	
	3	1.0	53.0		1.0	99.0		1.0	99.0	
	4	10.0	32.0		10.0	42.0		19.0	52.0	
	5	11.0	29.0		10.0	29.0		10.0	32.0	
	6	11.0	30.0		11.0	29.0		10.0	29.0	
	7	12.0	30.0		11.0	29.0		11.0	29.0	
	8	12.0	30.0		11.0	29.0		11.0	29.0	
	9	12.0	30.0		11.0	29.0		11.0	29.0	
	10	12.0	30.0		12.0	29.0		11.0	29.0	
	11	12.0	30.0		12.0	29.0		11.0	29.0	

HOUR 1 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	99.0	0.0	0.0	1.0	1.0	0.0	0.0	
2	48.0	54.0	7.3	10.0	0.0	0.0	0.0	
3	98.3	0.9	0.9	1.0	0.0	0.0	0.0	
4	99.0	0.0	0.0	1.0	0.0	0.0	0.0	
1 2	73.5	677.3	26.0	5.5	20.3	4.5		
1 3	98.7	0.6	0.7	1.0	0.0	0.0		
1 4	99.0	0.0	0.0	1.0	0.0	0.0		
2 3	73.2	650.8	25.7	5.5	20.3	4.5		
2 4	73.5	677.3	26.0	5.5	20.3	4.5		
3 4	98.7	0.6	0.7	1.0	0.0	0.0		
1 2 3 4	86.1	497.2	22.3	3.3	15.2	3.9		

HOUR 3 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	78.7	574.9	24.0	4.0	18.0	4.2		
2	38.3	5.6	2.4	10.7	0.2	0.5		
3	26.0	0.0	0.0	10.0	0.0	0.0		
4	83.7	470.2	21.7	6.0	18.0	4.2		
1 2	58.5	696.9	26.4	7.3	20.2	4.5		
1 3	52.3	980.9	31.3	7.0	18.0	4.2		
1 4	81.2	828.8	23.0	4.0	18.0	4.2		
2 3	32.2	40.8	6.4	10.3	0.2	0.5		
2 4	61.0	751.7	27.4	7.3	20.2	4.5		
3 4	54.8	1066.5	32.7	7.0	18.0	4.2		
1 2 3 4	56.7	885.1	29.7	7.2	19.1	4.4		

HOUR 5 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	47.7	26.9	5.2	10.7	0.2	0.5		
2	41.3	4.2	2.1	11.3	0.2	0.5		
3	28.7	0.2	0.5	11.7	0.2	0.5		
4	30.0	2.0	1.4	10.3	0.2	0.5		
1 2	44.5	25.6	5.1	11.0	0.3	0.5		
1 3	38.2	103.8	10.2	11.2	0.5	0.7		
1 4	38.8	92.5	9.6	10.5	0.3	0.5		
2 3	35.0	42.3	6.5	11.5	0.3	0.5		
2 4	35.7	35.2	5.9	10.8	0.5	0.7		
3 4	29.3	1.6	1.2	11.0	0.7	0.8		
1 2 3 4	36.9	71.1	8.4	11.0	0.5	0.7		

HOUR 2 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	93.7	56.9	7.5	1.0	0.0	0.0		
2	39.3	0.2	0.5	10.7	0.2	0.5		
3	37.0	60.7	7.8	19.3	43.6	6.6		
4	99.0	0.0	0.0	1.0	0.0	0.0		
1 2	66.5	766.6	27.7	5.8	23.5	4.8		
1 3	65.3	861.6	29.4	10.2	105.8	10.3		
1 4	95.3	35.6	6.0	1.0	0.0	0.0		
2 3	38.2	31.8	5.6	15.0	40.7	6.4		
2 4	69.2	890.1	29.8	5.8	23.5	4.8		
3 4	68.0	991.3	31.5	10.2	105.8	10.3		
1 2 3 4	67.3	879.5	29.7	8.0	69.3	8.3		

HOUR 4 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	54.3	113.6	10.7	13.7	20.2	4.5		
2	40.0	6.0	2.4	11.3	0.2	0.5		
3	26.0	0.0	0.0	10.7	0.2	0.5		
4	42.0	66.7	8.2	13.0	18.0	4.2		
1 2	47.2	111.1	10.5	12.5	11.6	3.4		
1 3	40.2	257.5	16.0	12.2	12.5	3.5		
1 4	48.2	128.1	11.3	13.3	19.2	4.4		
2 3	33.0	52.0	7.2	11.0	0.3	0.6		
2 4	41.0	37.3	6.1	12.2	9.8	3.1		
3 4	34.0	97.3	9.9	11.8	10.5	3.2		
1 2 3 4	40.6	147.6	12.1	12.2	11.1	3.3		

HOUR 6 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	MEAN ANGLE (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	
1	45.7	14.9	3.9	10.7	0.2	0.5		
2	42.3	1.6	1.2	11.7	0.2	0.5		
3	28.3	0.9	0.9	11.3	0.2	0.5		
4	29.3	0.2	0.5	10.7	0.2	0.5		
1 2	44.0	11.0	3.3	11.2	0.3	0.7		
1 3	37.0	83.0	9.1	11.0	0.3	0.6		
1 4	37.5	74.3	8.6	10.7	0.2	0.5		
2 3	35.3	50.2	7.1	11.5	0.3	0.5		
2 4	35.8	43.1	6.6	11.2	0.5	0.7		
3 4	28.6	0.8	0.9	11.0	0.3	0.6		
1 2 3 4	36.4	63.4	8.0	11.1	0.4	0.6		

HOUR 7 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	44.7	10.9	3.3	11.0	0.7	0.8		
2	36.0	2.0	1.4	11.7	0.2	0.5		
3	29.7	0.2	0.5	11.3	0.2	0.5		
4	29.3	0.2	0.5	11.3	0.2	0.5		
1 2	41.3	17.6	4.2	11.3	0.6	0.7		
1 3	37.2	61.8	7.9	11.2	0.5	0.7		
1 4	37.0	64.3	8.0	11.2	0.5	0.7		
2 3	33.8	18.5	4.3	11.5	0.3	0.5		
2 4	33.7	19.9	4.9	11.5	0.3	0.5		
3 4	29.5	0.3	0.5	11.3	0.2	0.5		
1 2 3 4	35.4	43.9	6.6	11.3	0.4	0.6		

HOUR 9 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	42.3	29.6	5.4	11.0	0.7	0.8		
2	35.0	0.7	0.8	11.3	0.2	0.5		
3	31.0	2.0	1.4	11.0	0.0	0.0		
4	29.3	0.2	0.5	11.7	0.2	0.5		
1 2	38.7	28.6	5.3	11.2	0.5	0.7		
1 3	36.7	47.9	6.9	11.0	0.3	0.6		
1 4	35.8	57.1	7.6	11.3	0.6	0.7		
2 3	33.0	5.3	2.3	11.2	0.1	0.4		
2 4	32.2	8.5	2.9	11.5	0.3	0.5		
3 4	30.2	1.9	1.3	11.3	0.2	0.5		
1 2 3 4	34.4	33.2	5.8	11.3	0.4	0.6		

HOUR 11 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	75.7	758.2	27.5	4.3	22.2	4.7		
2	83.7	470.2	21.7	4.0	18.0	4.2		
3	27.0	2.0	1.4	10.7	0.2	0.5		
4	29.3	0.2	0.5	11.7	0.2	0.5		
1 2	79.7	630.2	25.1	4.2	20.1	4.5		
1 3	51.3	972.2	31.2	7.5	21.3	4.6		
1 4	52.5	915.9	30.3	8.0	24.7	5.0		
2 3	55.3	1038.9	32.2	7.3	20.2	4.5		
2 4	56.5	973.3	31.2	7.8	23.8	4.9		
3 4	28.2	2.5	1.6	11.2	0.5	0.7		
1 2 3 4	53.9	979.4	31.3	7.7	22.6	4.7		

HOUR 8 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	40.3	16.2	4.0	11.0	0.7	0.8		
2	35.3	0.9	0.9	11.7	0.2	0.5		
3	30.3	0.2	0.5	11.0	0.0	0.0		
4	29.3	0.2	0.5	11.3	0.2	0.5		
1 2	37.8	14.8	3.8	11.3	0.6	0.7		
1 3	35.3	33.2	5.8	11.0	0.3	0.6		
1 4	34.8	38.5	6.2	11.2	0.5	0.7		
2 3	32.8	6.8	2.6	11.3	0.2	0.5		
2 4	32.3	9.6	3.1	11.5	0.3	0.5		
3 4	29.8	0.5	0.7	11.2	0.1	0.4		
1 2 3 4	33.6	23.6	4.9	11.3	0.4	0.6		

HOUR 10 (UT)  
 TRANSMITTER DISTANCE OF 4000 KM. STATISTICS FOR THREE MONTHS  
 (APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	49.3	113.6	10.7	14.3	16.2	4.0		
2	47.3	113.6	10.7	13.7	14.2	3.8		
3	30.3	0.2	0.5	11.0	0.0	0.0		
4	29.3	0.2	0.5	11.7	0.2	0.5		
1 2	48.3	114.6	10.7	14.0	15.3	3.9		
1 3	39.8	147.1	12.1	12.7	10.9	3.3		
1 4	39.3	156.9	12.5	13.0	10.0	3.2		
2 3	38.8	129.1	11.4	12.3	8.9	3.0		
2 4	38.3	137.9	11.7	12.7	8.2	2.9		
3 4	29.8	0.5	0.7	11.3	0.2	0.5		
1 2 3 4	39.1	143.1	12.0	12.7	9.6	3.1		

# TRANSMITTER POWER AND ARRIVAL ANGLE ESTIMATES FOR 5000 km.

BEARING (DEG)	HOUR (UT)	April			May			June		
		ARRIVAL ANGLE (DEG)	POWER (DBW)	ARRIVAL ANGLE (DEG)	ARRIVAL ANGLE (DEG)	POWER (DBW)	ARRIVAL ANGLE (DEG)	ARRIVAL ANGLE (DEG)	POWER (DBW)	ARRIVAL ANGLE (DEG)
0.0	1	2.0	99.0	2.0	99.0	99.0	2.0	2.0	99.0	
	2	3.0	93.0		2.0	99.0		2.0	99.0	
	3	8.0	50.0	20.0	86.0	86.0		2.0	99.0	
	4	8.0	46.0		8.0	63.0		8.0	79.0	
	5	8.0	47.0		8.0	57.0		8.0	73.0	
	6	9.0	46.0		8.0	54.0		8.0	69.0	
	7	9.0	45.0		8.0	54.0		8.0	68.0	
	8	9.0	42.0		8.0	52.0		8.0	67.0	
	9	9.0	43.0		8.0	54.0		8.0	70.0	
	10	9.0	44.0		8.0	60.0		8.0	76.0	
	11	8.0	99.0	20.0		85.0		2.0	99.0	
90.0	1	8.0	47.0	8.0	8.0	51.0		8.0	58.0	
	2	9.0	42.0		8.0	45.0		8.0	47.0	
	3	9.0	43.0		9.0	42.0		8.0	39.0	
	4	9.0	42.0		9.0	43.0		9.0	39.0	
	5	9.0	45.0		9.0	43.0		9.0	39.0	
	6	9.0	44.0		9.0	42.0		9.0	38.0	
	7	9.0	41.0		9.0	39.0		9.0	38.0	
	8	9.0	38.0		9.0	37.0		9.0	37.0	
	9	9.0	39.0		9.0	43.0		8.0	48.0	
	10	8.0	52.0		8.0	63.0		8.0	72.0	
	11	13.0	83.0	3.0		99.0		2.0	99.0	
180.0	1	2.0	99.0	2.0	99.0	99.0	2.0	2.0	99.0	
	2	8.0	32.0	8.0	44.0	44.0		13.0	50.0	
	3	8.0	32.0		8.0	31.0		8.0	31.0	
	4	9.0	32.0		9.0	31.0		8.0	31.0	
	5	9.0	32.0		9.0	31.0		9.0	31.0	
	6	9.0	32.0		9.0	31.0		9.0	31.0	
	7	8.0	32.0		9.0	31.0		8.0	33.0	
	8	8.0	32.0		8.0	31.0		8.0	33.0	
	9	8.0	32.0		8.0	31.0		8.0	35.0	
	10	8.0	32.0		8.0	31.0		8.0	34.0	
	11	8.0	30.0	8.0		31.0		8.0	33.0	
270.0	1	2.0	99.0	2.0	99.0	99.0	2.0	2.0	99.0	
	2	2.0	99.0		2.0	99.0		2.0	99.0	
	3	12.0	84.0		3.0	99.0		2.0	99.0	
	4	12.0	52.0	12.0	68.0	68.0		12.0	79.0	
	5	8.0	34.0	8.0	42.0	42.0		12.0	49.0	
	6	9.0	35.0		8.0	33.0		8.0	33.0	
	7	9.0	35.0		8.0	33.0		8.0	33.0	
	8	9.0	35.0		9.0	33.0		9.0	33.0	
	9	9.0	33.0		9.0	32.0		9.0	32.0	
	10	9.0	33.0		9.0	32.0		9.0	32.0	
	11	9.0	33.0	9.0		32.0		9.0	32.0	

NOUR 1 (UT)											
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS (APRIL, MAY, JUNE)											
BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS		BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS		ARRIVAL ANGLE STATISTICS	
	MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)		MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)
1	99.0	0.0	2.0	0.0	1	70.3	429.6	20.7	10.0	56.0	7.5
2	52.0	20.7	0.0	0.0	2	41.3	2.9	1.7	0.7	0.2	0.5
3	99.0	0.0	2.0	0.0	3	31.3	0.0	0.5	8.0	0.0	0.0
4	99.0	0.0	2.0	0.0	4	94.0	50.0	7.1	5.7	20.2	4.5
1 2	75.5	562.6	23.7	5.0	1 2	59.0	558.5	23.6	9.3	28.6	5.3
1 3	99.0	0.0	2.0	0.0	1 3	54.0	767.1	27.7	9.0	29.0	5.4
1 4	99.0	0.0	2.0	0.0	1 4	86.2	301.1	17.4	7.8	42.8	6.5
2 3	75.5	562.6	23.7	5.0	2 3	36.3	26.6	5.2	8.3	0.2	0.5
2 4	75.5	562.6	23.7	5.0	2 4	67.7	719.9	26.0	7.2	12.5	3.5
3 4	99.0	0.0	2.0	0.0	3 4	62.7	1006.9	31.7	6.8	11.5	3.4
1 2 3 4	87.3	419.4	20.5	3.5	1 2 3 4	61.3	784.7	28.0	8.1	21.6	4.6

NOUR 2 (UT)											
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS (APRIL, MAY, JUNE)											
BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS		BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS		ARRIVAL ANGLE STATISTICS	
	MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)		MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)
1	97.0	0.0	2.0	0.5	1	62.7	181.6	13.5	8.0	0.0	0.0
2	44.7	4.2	0.3	0.5	2	41.3	2.9	1.7	8.7	0.2	0.5
3	42.0	56.0	7.5	2.4	3	31.3	0.2	0.5	8.7	0.2	0.5
4	99.0	0.0	2.0	0.0	4	66.3	122.9	11.1	12.0	0.0	0.0
1 2	70.8	690.8	26.3	3.0	1 2	52.0	206.0	14.4	8.3	0.2	0.5
1 3	69.5	788.3	20.1	6.0	1 3	47.0	336.3	18.3	8.3	0.2	0.5
1 4	98.0	5.0	2.2	0.4	1 4	64.5	155.6	12.5	10.0	2.0	0.5
2 3	43.3	31.9	5.6	3.3	2 3	36.3	26.6	5.2	8.7	0.2	0.5
2 4	71.8	740.1	27.2	5.2	2 4	53.8	219.1	14.8	10.3	2.9	1.7
3 4	70.5	840.3	29.0	5.0	3 4	48.8	387.8	19.2	10.3	2.9	1.7
1 2 3 4	70.7	765.6	27.7	5.6	1 2 3 4	50.4	289.4	17.0	9.3	2.6	1.6

NOUR 3 (UT)											
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS (APRIL, MAY, JUNE)											
BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS		BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS		ARRIVAL ANGLE STATISTICS	
	MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)		MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)
1	99.0	0.0	2.0	0.0	1	59.0	114.7	10.7	8.0	0.0	0.0
2	52.0	20.7	0.0	0.0	2	42.3	6.2	2.5	9.0	0.0	0.0
3	99.0	0.0	2.0	0.0	3	31.3	0.2	0.5	9.0	0.0	0.0
4	99.0	0.0	2.0	0.0	4	41.7	37.6	6.1	9.3	3.6	1.9
1 2	75.5	562.6	23.7	5.0	1 2	50.7	129.9	11.4	8.5	0.3	0.5
1 3	99.0	0.0	2.0	0.0	1 3	45.2	249.8	15.0	8.5	0.3	0.5
1 4	99.0	0.0	2.0	0.0	1 4	50.3	151.2	12.3	8.7	2.2	1.5
2 3	75.5	562.6	23.7	5.0	2 3	36.0	33.5	5.0	9.0	0.0	0.0
2 4	75.5	562.6	23.7	5.0	2 4	42.0	22.0	4.7	9.2	1.8	1.3
3 4	99.0	0.0	2.0	0.0	3 4	36.5	45.6	6.8	9.2	1.8	1.3
1 2 3 4	87.3	419.4	20.5	3.5	1 2 3 4	43.6	137.9	11.7	8.6	1.1	1.1

NOUR 4 (UT)											
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS (APRIL, MAY, JUNE)											
BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS		BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS		ARRIVAL ANGLE STATISTICS	
	MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)		MEAN POWER (08M)	STANDARD DEVIATION (08)	MEAN ANGLE (06G)	STANDARD DEVIATION (06G)
1	97.0	0.0	2.0	0.5	1	56.3	90.9	9.5	8.3	0.2	0.5
2	44.7	4.2	0.3	0.5	2	41.3	6.2	2.5	9.0	0.0	0.0
3	42.0	56.0	7.5	2.4	3	31.3	0.2	0.5	9.0	0.0	0.0
4	99.0	0.0	2.0	0.0	4	32.7	0.9	0.9	8.3	0.2	0.5
1 2	70.8	690.8	26.3	3.0	1 2	48.8	104.8	10.2	8.7	0.2	0.5
1 3	69.5	788.3	20.1	6.0	1 3	43.8	201.8	14.2	8.7	0.2	0.5
1 4	98.0	5.0	2.2	0.4	1 4	45.0	174.3	13.2	8.3	0.2	0.5
2 3	43.3	31.9	5.6	3.3	2 3	36.3	28.2	5.3	9.0	0.0	0.0
2 4	71.8	740.1	27.2	5.2	2 4	37.5	19.3	4.3	8.7	0.2	0.5
3 4	70.5	840.3	29.0	5.0	3 4	32.5	1.9	1.4	8.7	0.2	0.5
1 2 3 4	70.7	765.6	27.7	5.6	1 2 3 4	40.7	120.1	11.0	8.7	0.2	0.5

MOOR 7 (UT)  
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	55.7	99.6	9.5	0.5	8.3	0.2	0.5	
2	39.2	1.6	1.2	0.0	9.0	0.0	0.0	
3	32.0	0.7	0.8	0.5	8.3	0.2	0.5	
4	33.7	0.9	0.9	0.5	8.3	0.2	0.5	
1 2	47.5	112.3	10.6	0.2	8.7	0.2	0.5	
1 3	43.8	185.1	13.6	0.2	8.3	0.2	0.5	
1 4	44.7	186.2	12.9	0.2	8.3	0.2	0.5	
2 3	35.7	14.6	3.8	0.2	8.7	0.2	0.5	
2 4	36.5	9.3	3.0	0.2	8.7	0.2	0.5	
3 4	32.8	1.5	1.2	0.2	8.3	0.2	0.5	
1 2 3 4	40.2	110.6	10.5	0.3	8.5	0.3	0.5	

MOOR 9 (UT)  
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	55.7	122.9	11.1	0.5	8.3	0.2	0.5	
2	43.3	13.6	3.7	0.2	8.7	0.2	0.5	
3	32.7	2.9	1.7	0.0	8.0	0.0	0.0	
4	32.3	0.2	0.5	0.0	9.0	0.0	0.0	
1 2	49.5	106.3	10.3	0.3	8.5	0.3	0.5	
1 3	44.2	195.1	14.0	0.1	8.2	0.1	0.4	
1 4	44.0	197.7	14.1	0.2	8.7	0.2	0.5	
2 3	38.0	36.7	6.1	0.2	8.3	0.2	0.5	
2 4	37.8	37.1	6.1	0.1	8.8	0.1	0.4	
3 4	32.5	1.6	1.3	0.3	8.5	0.3	0.5	
1 2 3 4	41.0	126.2	11.2	0.3	8.5	0.3	0.5	

MOOR 11 (UT)  
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	94.3	43.6	6.6	10.0	56.0	56.0	7.5	
2	93.7	56.9	7.5	6.0	24.7	24.7	5.0	
3	31.3	1.6	1.2	8.0	0.0	0.0	0.0	
4	32.3	0.2	0.5	9.0	0.0	0.0	0.0	
1 2	94.0	50.3	7.1	8.0	44.3	44.3	6.7	
1 3	62.8	1014.8	31.9	9.0	29.0	29.0	5.4	
1 4	63.3	982.9	31.4	9.5	28.3	28.3	5.3	
2 3	62.5	1000.6	31.6	7.0	13.3	13.3	3.7	
2 4	63.0	969.0	31.1	7.5	14.6	14.6	3.8	
3 4	31.8	1.1	1.1	8.5	0.3	0.3	0.5	
1 2 3 4	62.9	991.9	31.5	8.3	22.4	22.4	4.7	

MOOR 8 (UT)  
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	53.7	105.6	10.3	0.2	8.3	0.2	0.5	
2	37.3	0.2	0.5	0.0	9.0	0.0	0.0	
3	32.0	0.7	0.8	0.0	8.0	0.0	0.0	
4	33.7	0.9	0.9	0.0	9.0	0.0	0.0	
1 2	45.5	119.6	10.9	0.2	8.7	0.2	0.5	
1 3	42.8	170.5	13.1	0.1	8.2	0.1	0.4	
1 4	43.7	153.2	12.4	0.2	8.7	0.2	0.5	
2 3	34.7	7.6	2.7	0.3	8.5	0.3	0.5	
2 4	35.5	3.9	2.0	0.0	9.0	0.0	0.0	
3 4	32.9	1.5	1.2	0.3	8.5	0.3	0.5	
1 2 3 4	39.2	100.6	10.0	0.2	8.6	0.2	0.5	

MOOR 10 (UT)  
TRANSMITTER DISTANCE OF 5000 KM. STATISTICS FOR THREE MONTHS  
(APRIL, MAY, JUNE)

BEARING FROM RECEIVER	TRANSMITTER POWER STATISTICS				ARRIVAL ANGLE STATISTICS			
	MEAN POWER (DBM)	VARIANCE (DBM)	STANDARD DEVIATION (DB)	STANDARD DEVIATION (DEG)	MEAN ANGLE (DEG)	VARIANCE (DEG)	STANDARD DEVIATION (DEG)	STANDARD DEVIATION (DEG)
1	60.0	170.7	13.1	8.3	0.2	0.5		
2	62.3	66.9	8.2	8.0	0.0	0.0		
3	32.3	1.6	1.2	8.0	0.0	0.0		
4	32.3	0.2	0.5	9.0	0.0	0.0		
1 2	61.2	120.1	11.0	8.2	0.1	0.4		
1 3	46.2	277.5	16.7	8.2	0.1	0.4		
1 4	46.2	276.8	16.6	8.7	0.2	0.5		
2 3	47.3	259.2	16.1	8.0	0.0	0.0		
2 4	47.3	258.6	16.1	8.5	0.3	0.5		
3 4	32.3	0.9	0.9	8.5	0.3	0.5		
1 2 3 4	46.8	268.4	16.4	8.3	0.2	0.5		

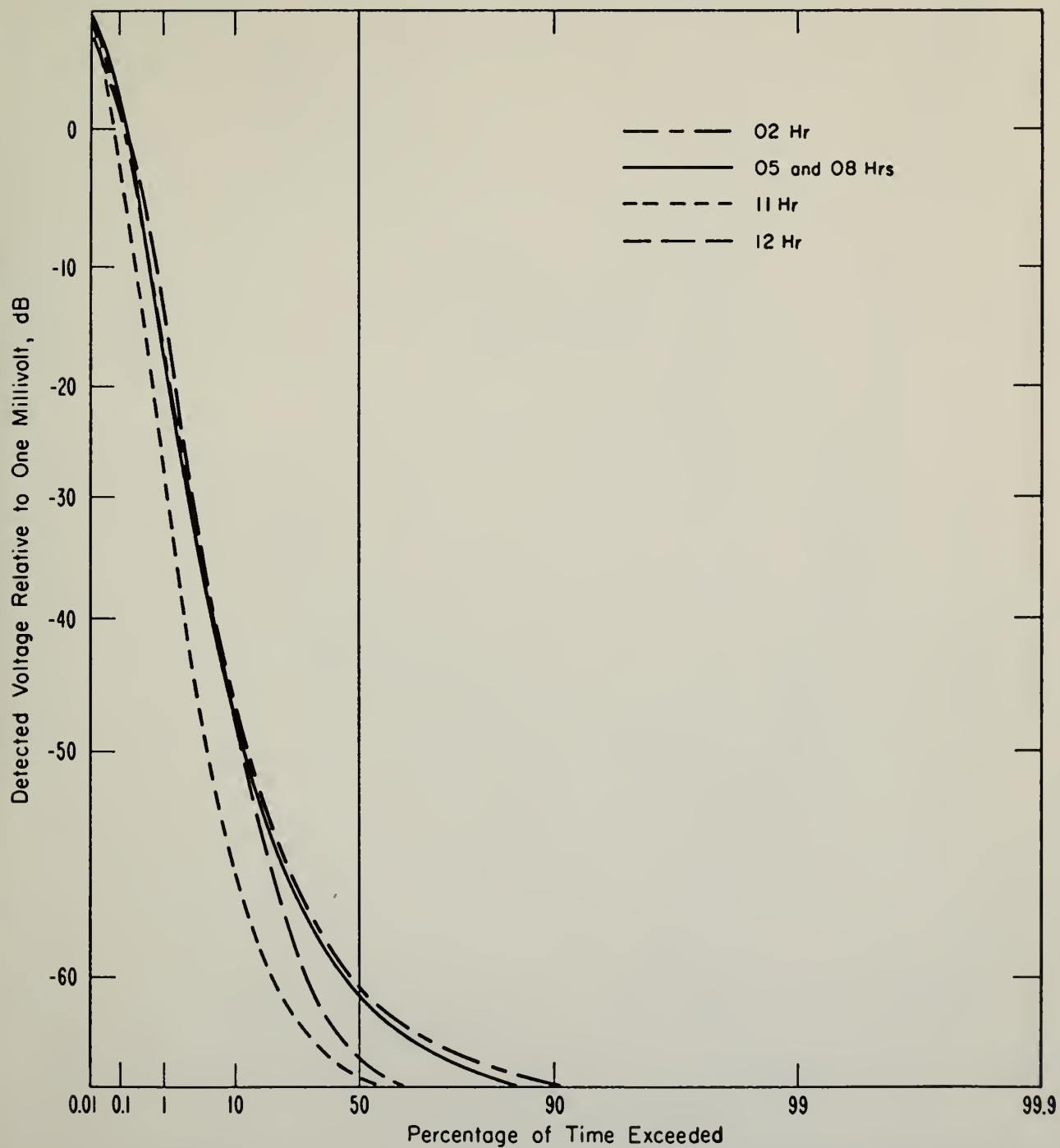
## APPENDIX D

### A Collection of Amplitude Probability Distributions

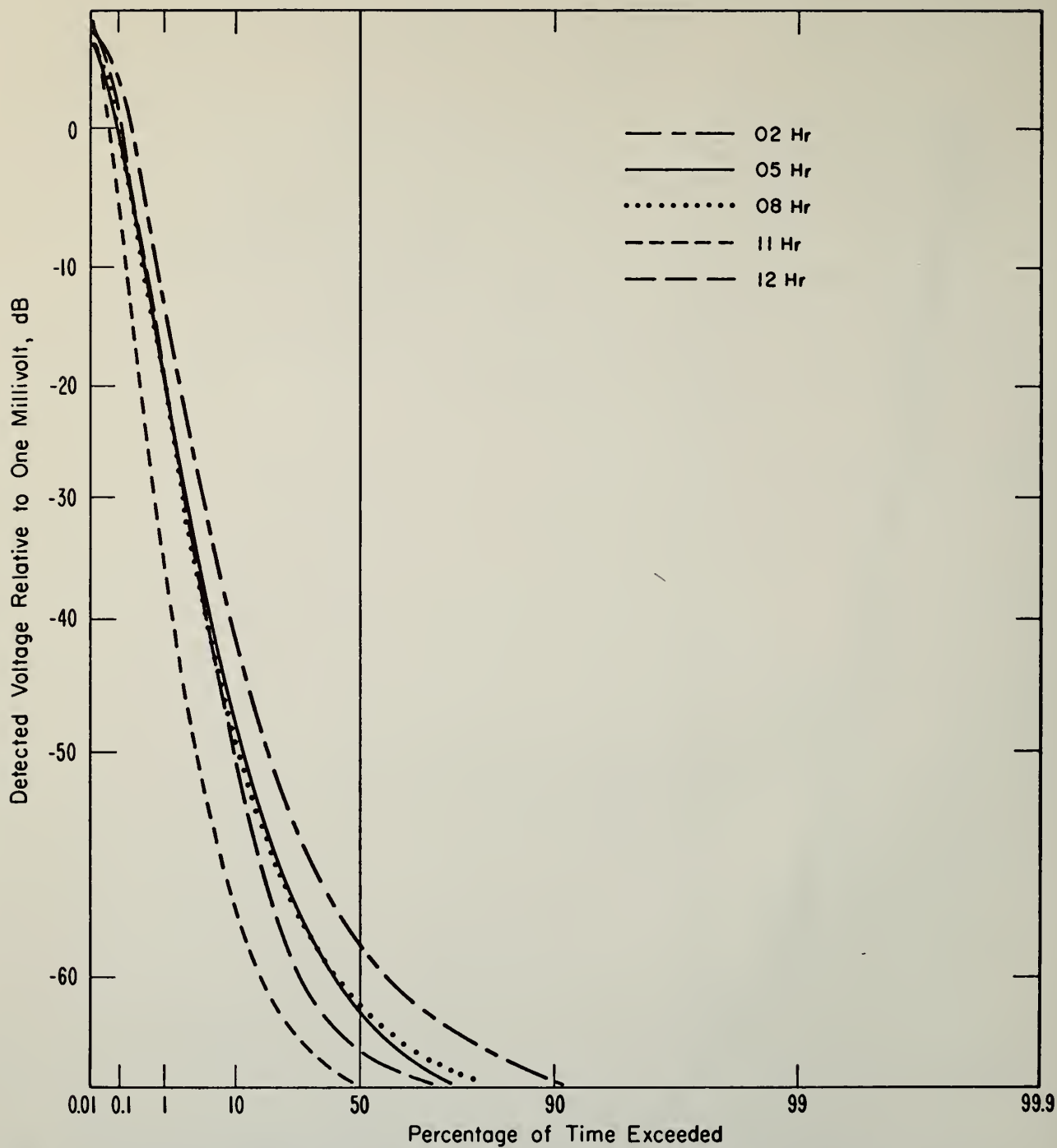
This appendix contains a sample of the amplitude probability distribution function analysis for one night (April 4 and 5, 1969; Day 94). The data for this date were recorded for hours 2, 5, 8, 11, and 12 UT, which corresponds to hours 19, 22, 1, 4, and 5 local time at the receiver.

Data for each hour consist of ten 5-min records, one each for ten 100-Hz receiving channels. The fifth 100-Hz step was centered on the desired Long Branch transmitter frequency of 2.666240 MHz.

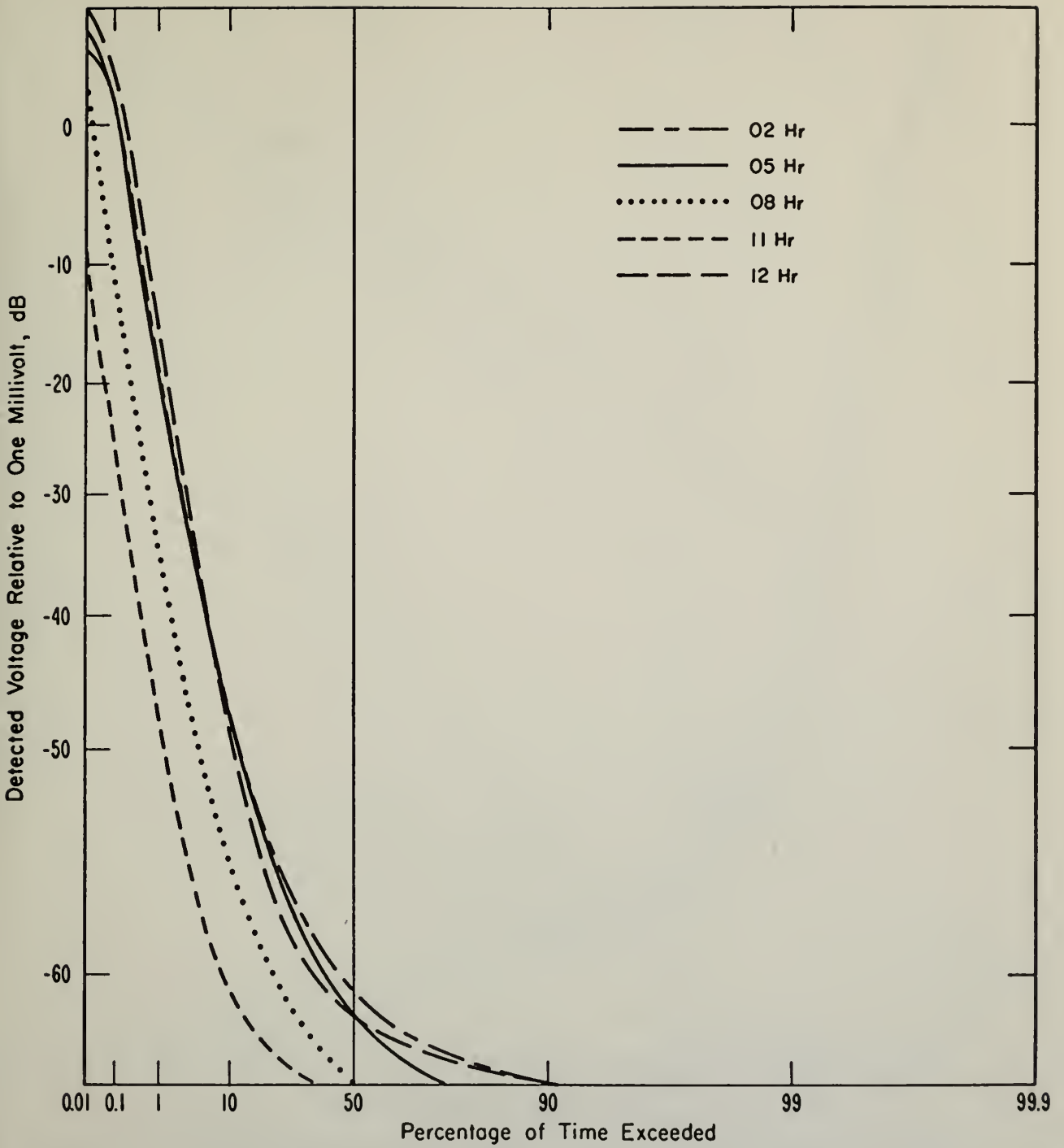
The plots are on modified Rayleigh probability paper. A Rayleigh cumulative distribution function would not yield a straight line on these plots due to the non-linear transfer function.



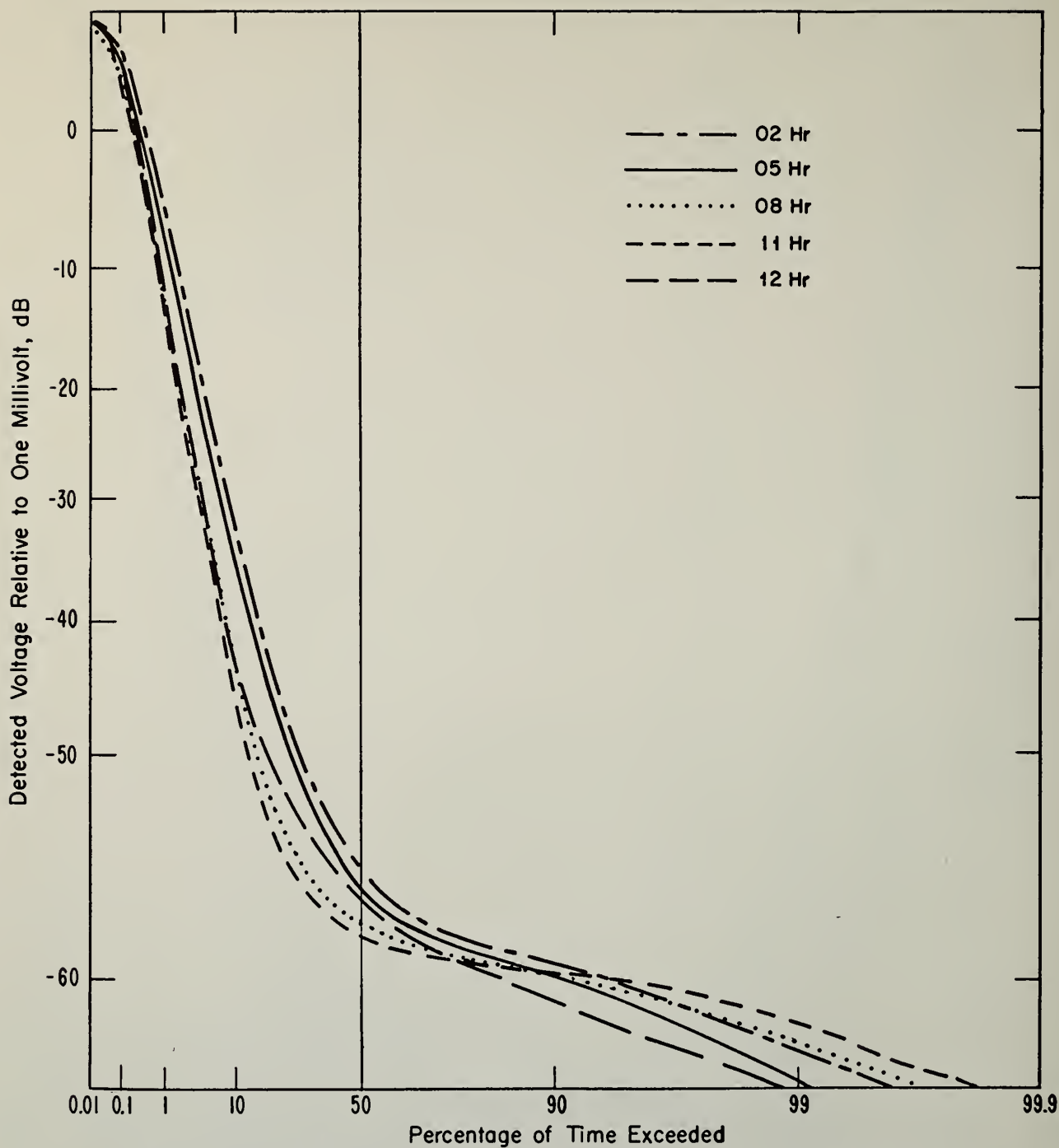
Record of channel No. 1 for day 94 -- identified as 00 min after the hour.



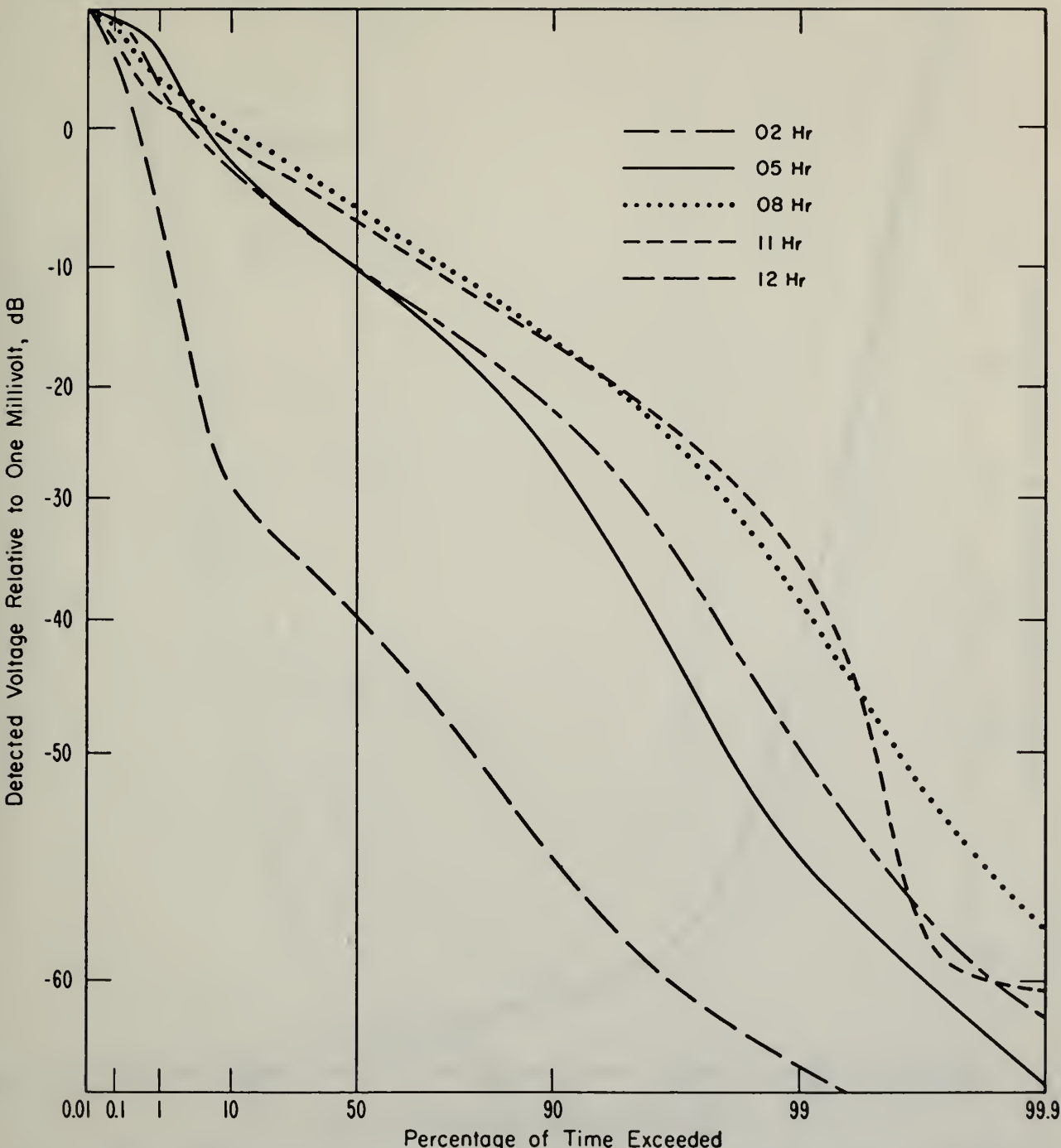
Record of channel No. 2 for day 94 -- identified as 05 min after the hour.



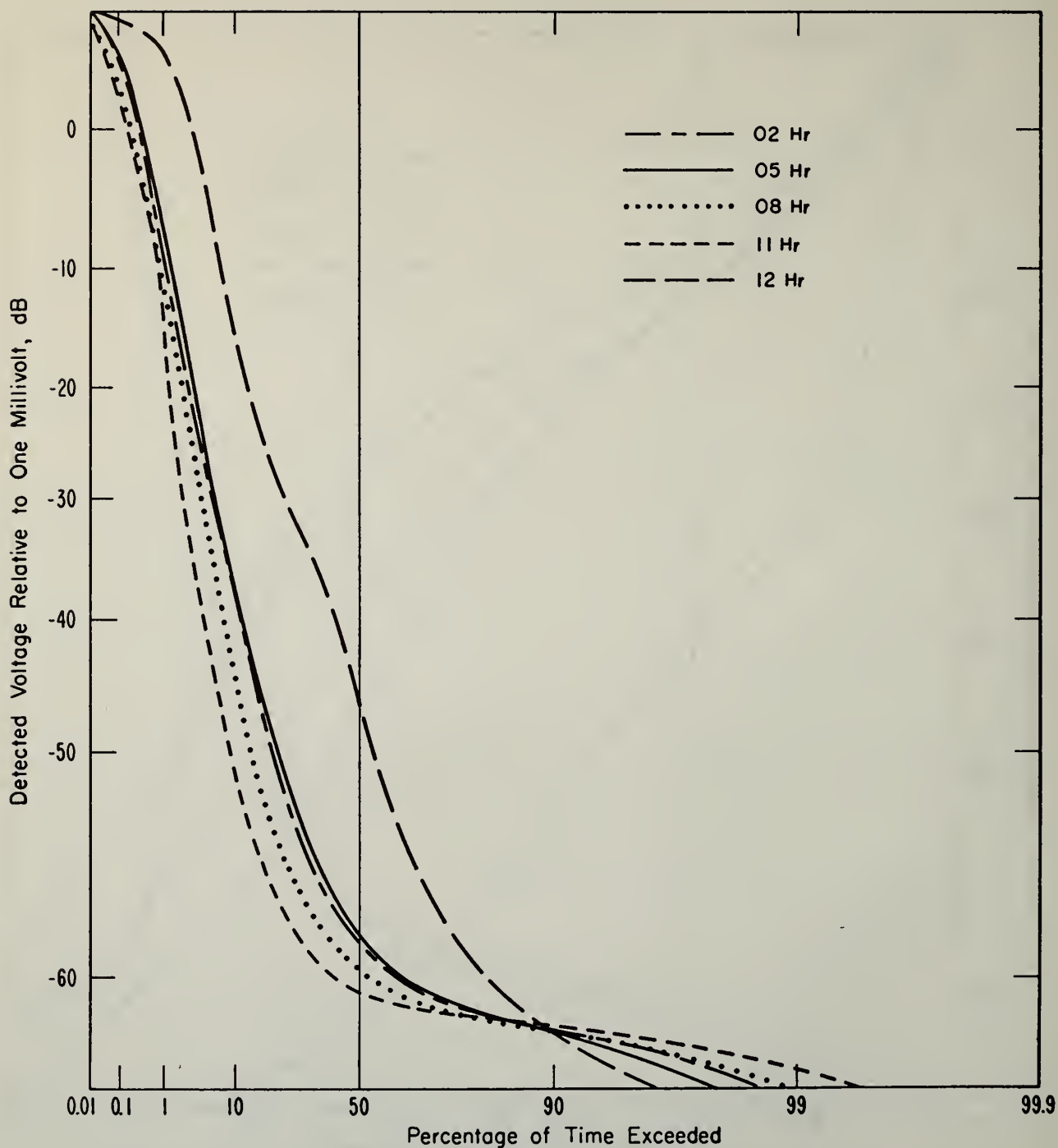
Record of channel No. 3 for day 94 -- identified as 10 min after the hour.



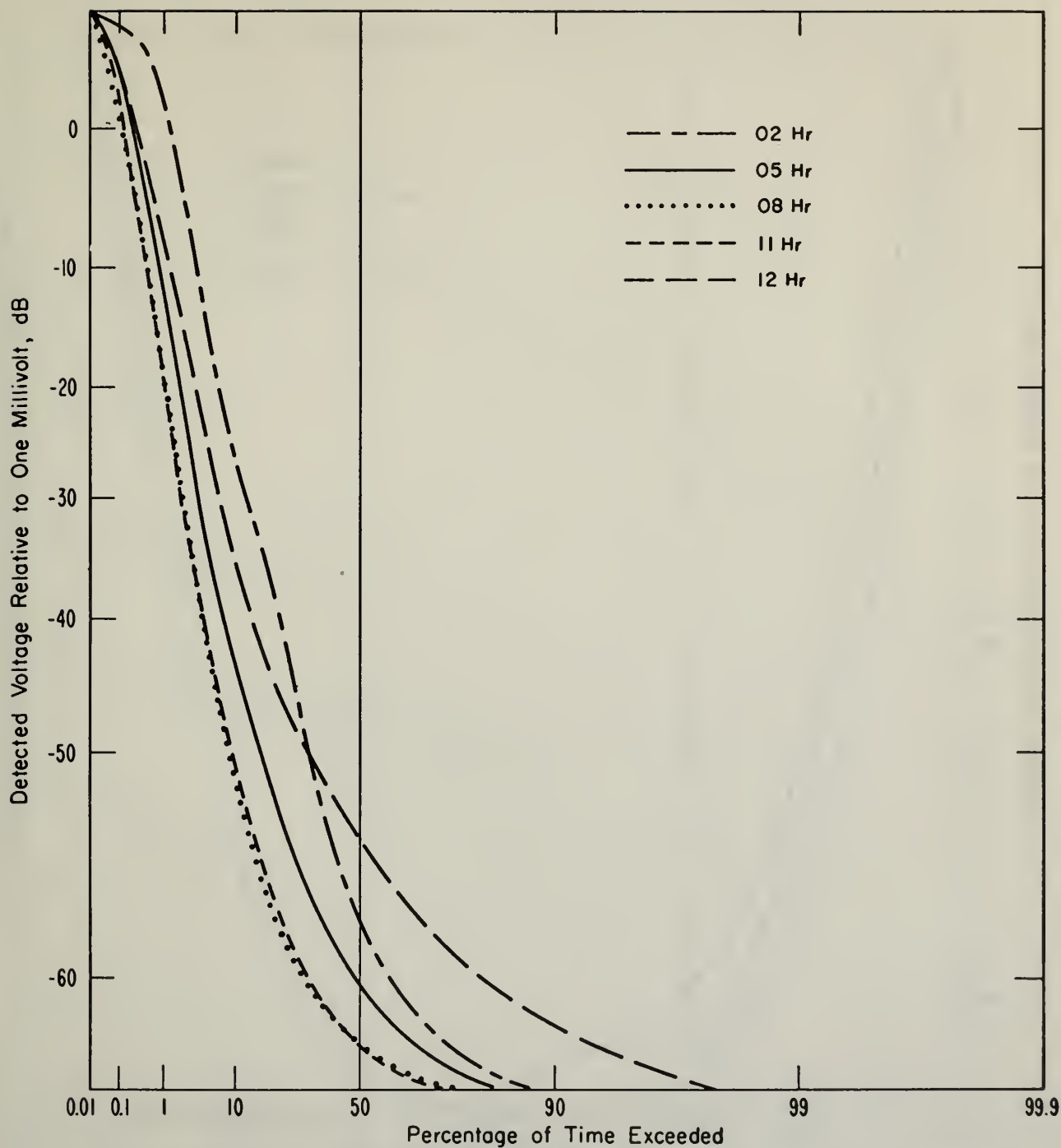
Record of channel No. 4 for day 94 -- identified as 15 min after the hour.



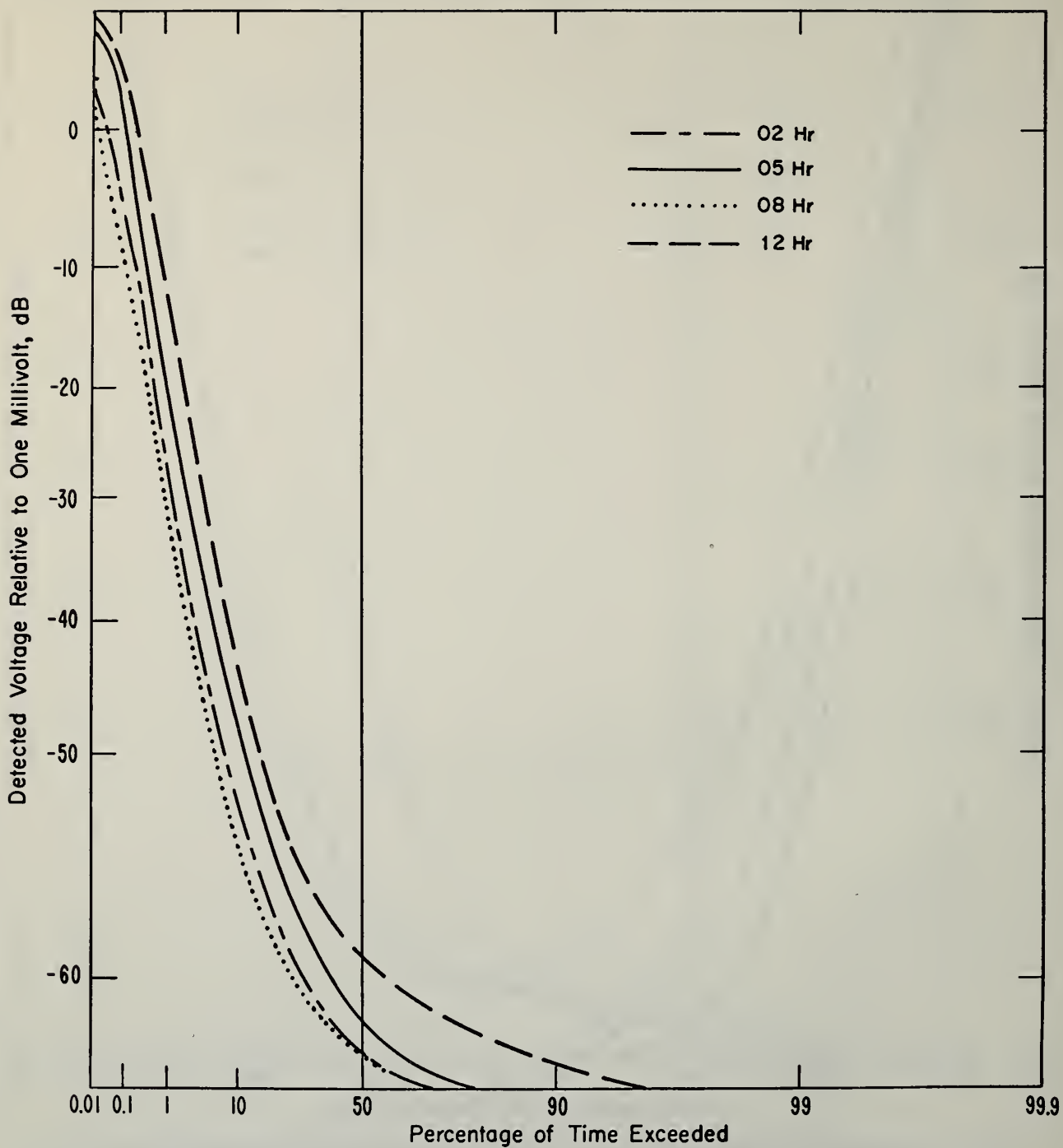
Record of channel No. 5 for day 94 -- identified as 20 min after the hour.



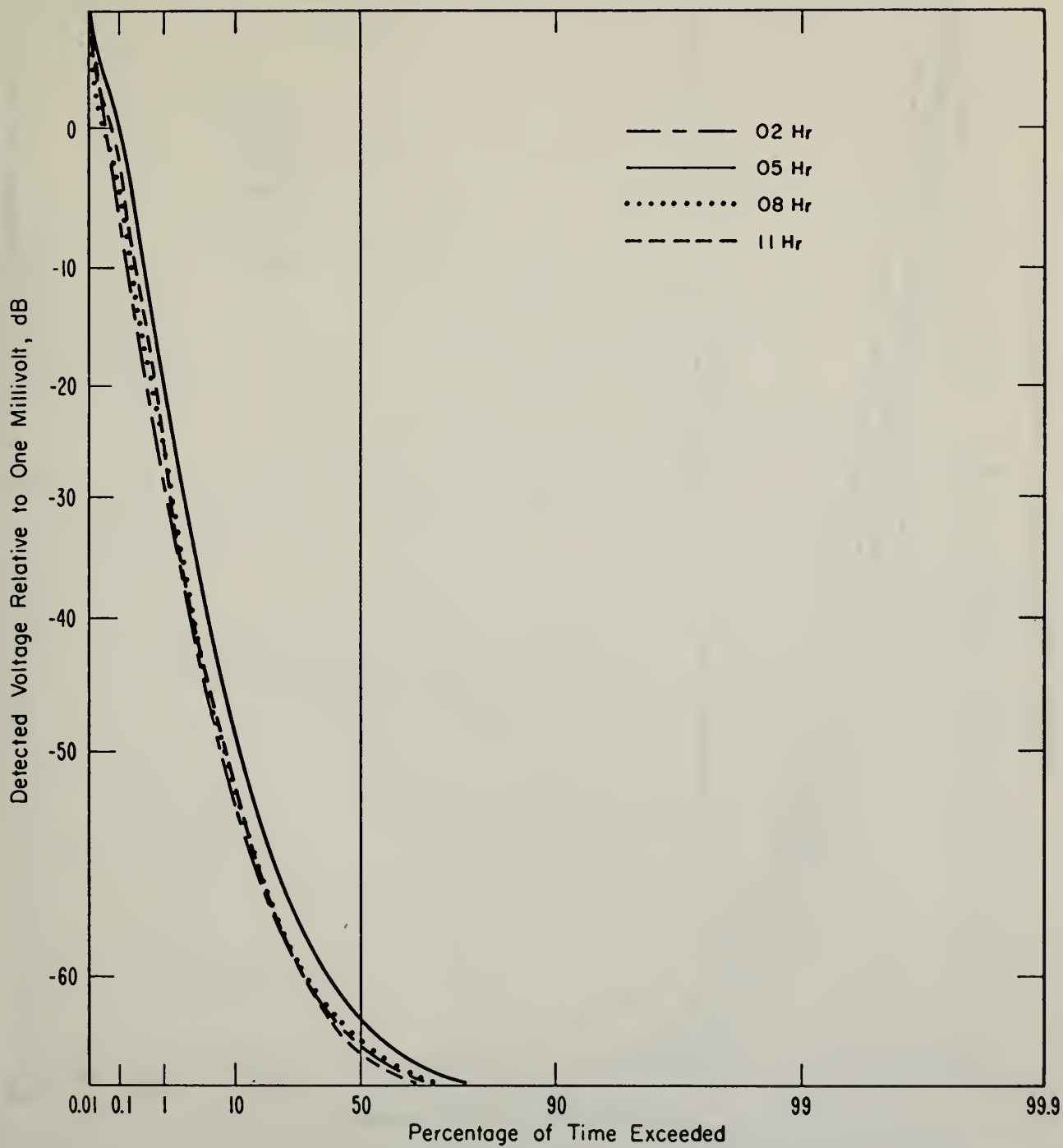
Record of channel No. 6 for day 94 -- identified as 25 min after the hour.



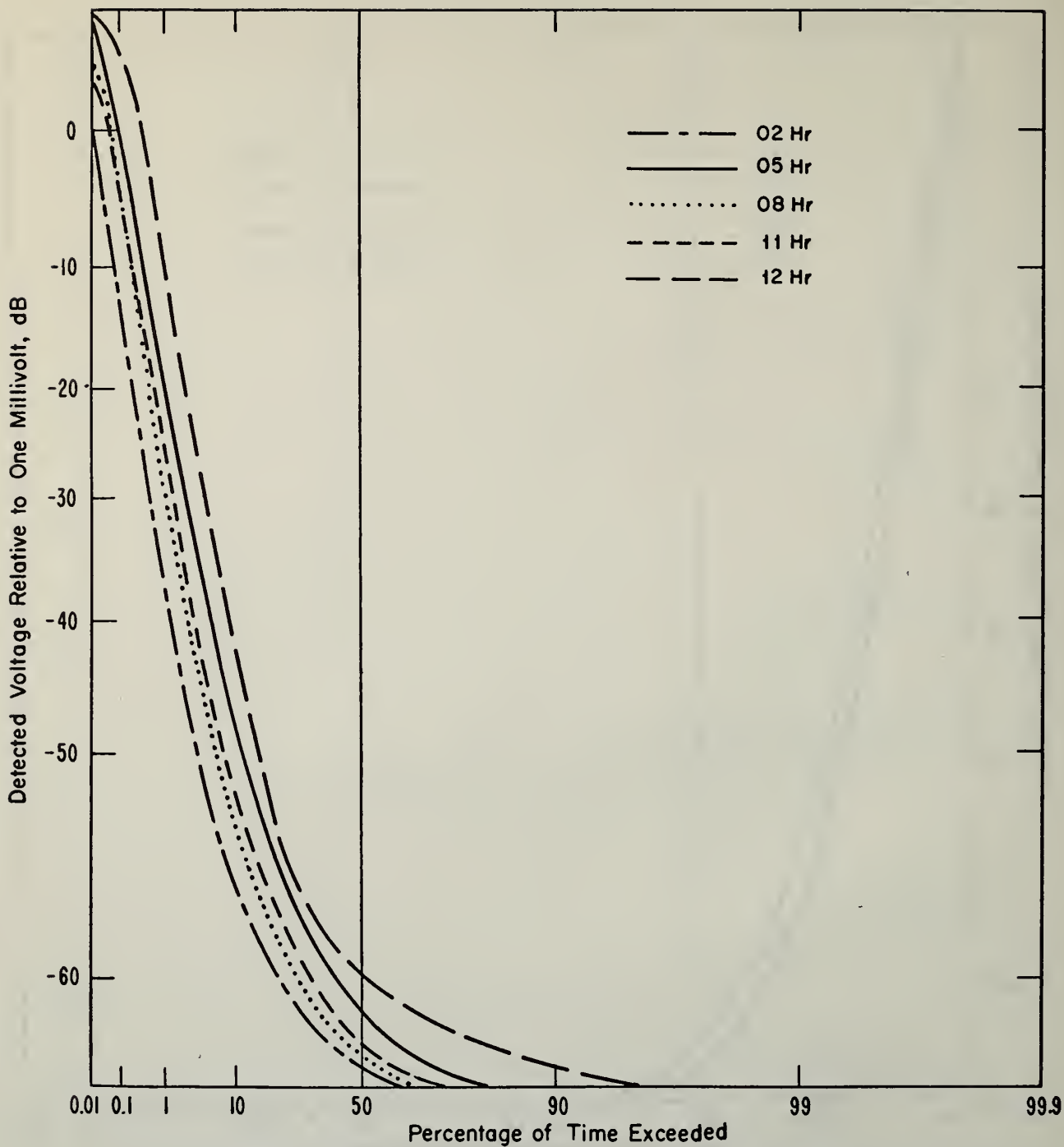
Record of channel No. 7 for day 94 -- identified as 30 min after the hour.



Record of channel No. 8 for day 94 -- identified as 35 min after the hour.



Record of channel No. 9 for day 94 -- identified as 40 min after the hour.



Record of channel No. 10 for day 94 -- identified as 45 min after the hour.







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